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CANNED FOOD CONTAINERS

A Study with Special Reference to the Influence of the Steel Base on Resistance to Perforation

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CANNED FOOD CONTAINERS

A Study with Special Reference to the Influence of the Steel Base on Resistance to Perforation

INVESTIGATION BY A COMMITTEE

REPRESENTING

NATIONAL CANNERS ASSOCIATION
AMERICAN CAN COMPANY
TITANIUM ALLOY MANUFACTURING COMPANY

WASHINGTON, D. C.
DECEMBER, 1923

CONTENTS

	PAGE
Introduction	17
Summary	21
Specific conclusions	21
General conclusions	21
Correlation of can service and variables in tin plate manufacture	22
Correlation by heats	22
General correlations	33
Production and testing of sheet bars	36
Furnace operation	36
Treatment in ladle	37
Treatment in molds	37
Heat treatment of ingots	40
Rolling	40
Shearing and selection of sample bars for experimental plate	41
Testing of sheet bars	42
Chemical tests	42
Physical tests	50
Tensile tests	50
Impact tests	55
Alternating-impact tests	56
Hardness tests	57
Rusting tests	58
Observations on physical tests	58
Metallographic tests	59
Production of tin plate	72
Hot mill practice	72
Black pickling	73
Black annealing	74
Cold rolling	79
White annealing	79
White pickling	82
Tinning	82
Assorting	84
Waster analyses	85
Selection of commercial plate	88
Testing of tin plate	89
Chemical analyses	89
Erichsen tests	95
Bending tests	96
Metallographic examination	98
Gelatine test	112
Rusting tests	114
Manufacture of cans	119
Experimental packs	120

PAGE

Inspection of fruits 121
Storage 121
Inspection procedure 121
Occurrence of springers and perforations 122
Relation of springers to perforations 123
Relation of titanium treatment of the steel to failures 126
Comparison of failures in commercial and experimental plate of the 1917 experiment 134
Relation of copper content of steel to failures 135
Effect of the use of silicon in the mold as a deoxidizer 136
Relation of weight of tin coating to failures 136
Effect of type of pot used in tinning 137
Variation in service value of cans made from plate of different heats 138
Comparison of the different lots of commercial plate of the 1917 experiment 139
Inspection of other products 173
Corn 173
Peas 173
Catsup 173

APPENDICES

I.—Raw materials 175
II.—Open-hearth furnace data 176
III.—Ladle and mold data 180
IV.—Data on individual ingots 182
V.—Chemical analyses of sheet bars 184
VI.—Manganese and phosphorus distribution between the half heats of 1919 experiment 188
VII.—Tensile tests of sheet bars 190
VIII.—Impact tests of sheet bars 196
IX.—Alternating-impact tests of sheet bars 199
X.—Hardness tests of sheet bars 202
XI.—Atmospheric corrosion tests of sheet bars 204
XII.—Metallographic tests of sheet bars 208
XIII.—Rolling, annealing and tinning of sheets 212
XIV.—Assorting of tin plate 225
XV.—Weight of tin coating on tin plate of 1917 experiment 228
XVI.—Weight of tin coating on rusted tin plate, 1917 experiment 234
XVII.—Analyses of steel from perforated cans of 1917 pack 239
XVIII.—Data on commercial tin plate 247
XIX.—Weight of tin coating on cans of 1919 tin plate 248
XX.—Phosphorus content of cans of 1919 tin plate 250
XXI.—Erichsen test on 1919 tin plate 252
XXII.—Bending tests on 1919 tin plate 254
XXIII.—Microscopic examination of tin plate 255
XXIV.—Gelatine test of 1917 tin plate 259
XXV.—Rusting tests of 1917 and 1919 tin plate 261

PAGE

XXVI.—Packing procedure..... 264
XXVII.—Method of recording failures..... 267
XXVIII.—Relation of springers to perforations..... 268
XXIX.—Failures as affected by use of titanium..... 270
XXX.—Failures in lots of experimental and commercial plate in 1917..... 278
XXXI.—Failures as affected by use of silicon in the mold as a deoxidizer ... 279
XXXII.—Failures as affected by the weight of tin coating..... 280
XXXIII.—Variation in failures by heats of steel..... 281
XXXIV.—Variation in failures in lots of commercial plate..... 283
XXXV.—Failures in each product of the 1917 experiment, by heats of steel 284

TABLES

TABLE. PAGE.

1.—Service values of tin plate of 1917 experiment under various conditions.. 23
2.—Correlation of can service with open-hearth furnace, ladle and mold data 24
3.—Correlation of can service with properties of steel in sheet bars..... 27
4.—Correlation of can service with results of inspection and analysis of tin plate..... 30
5.—Carbon, manganese, phosphorus, sulphur and copper content of steel as shown by ladle analysis, 1917 and 1919 experiments..... 39
6.—Average carbon, manganese, phosphorus, sulphur and copper content of steel in 1917 experiment, based on sheet-bar analyses..... 44
7.—Average carbon, manganese, phosphorus, sulphur, and titanium content of steel in 1919 experiment, based on sheet-bar analyses..... 45
8.—Average copper and silicon content of steel in 1919 experiment, based on sheet-bar analyses..... 46
9.—Segregation of carbon, manganese, phosphorus, and sulphur as shown by average composition of center and edge samples, all heats, non-copper ingots, regular and titanium-treated steel, 1917 experiment.... 47
10.—Segregation of carbon, manganese, phosphorus and sulphur as shown by average composition of center and edge samples, first three heats, copper and non-copper ingots, regular and titanium-treated steel, 1917 experiment..... 48
11.—Segregation of carbon, manganese, phosphorus, and sulphur as shown by average composition of center and edge samples, all heats, regular and titanium-treated steel, 1919 experiment..... 49
12.—Averages from lengthwise tensile tests, 1917 experiment..... 51
13.—Averages from transverse tensile tests, 1917 experiment..... 52
14.—Averages from transverse tensile tests, 1919 experiment..... 52
15.—Character and appearance of fractures as revealed by lengthwise and transverse tensile tests, 1917 and 1919 experiments..... 53
16.—Averages of impact and hardness tests, 1917 experiment..... 56
17.—Averages of impact tests, 1919 experiment..... 57
18.—Average slag grades and sulphide distribution, steel of 1917 and 1919 experiments..... 63
19.—Average grades for structure, steel of 1917 and 1919 experiments..... 66

TABLE. PAGE

20.—Average spoilage in opening and time required per 1,000 pounds in opening rolled packs at sheet mill 73
21.—Maximum temperatures reached at tops of lots of sheets in black annealing 74
22.—Maximum temperatures reached at tops of lots of sheets in white annealing 81
23.—Iron, copper, lead, arsenic and antimony content of tin used in 1917 experiment 82
24.—Average percentage of coke waster sheets, 1917 experiment 84
25.—Average percentage of prime sheets, 1919 experiment 84
26.—Percentage of wasters due to steel defects in total number of sheets, 1917 experiment 86
27.—Average number of steel defects per 100 sheets, 1919 experiment 86
28.—Percentage of waster defects due to steel defects, 1919 experiment 87
29.—Average weight of tin coating, in pounds per base box, on sheets of 1917 experiment 89
30.—Average weight of tin coating, in pounds per base box, on sheets from rusting test, 1917 experiment 90
31.—Range of carbon, manganese, phosphorus, and sulphur in steel base of failed cans of 1917 experiment 91
32.—Average content of carbon, manganese, phosphorus, and sulphur in failed cans of 1917 experiment 93
33.—Average weight of tin coating on cans of the 1919 experimental plate 94
34.—Phosphorus content of tin plate in cans of 1919 experiment 94
35.—Range of phosphorus content in representative cans of the 1919 experimental plate 95
36.—Averages of results of Erichsen tests on tin plate of 1919 experiment expressed as percentage of standard values 96
37.—Averages of results of bending tests, regular and titanium-treated plate, 1919 experiment 98
38.—Average gelatine test gradings, 1917 experimental plate 112
39.—Percentage of total perforations occurring in body of enameled cans, 1917 plate, by products and classes of plate 122
40.—Number and percentage of perforated enameled cans, 1917 plate, recorded as springers before perforation 124
41.—Number and percentage of perforated enameled cans, 1919 plate, recorded as springers before perforation 125
42.—Times at which failures reached 10 and 20 per cent, respectively, in cans of the regular and titanium-treated plate, 1917 experiment 128
43.—Times at which failures reached 10 per cent in enameled cans of the regular and titanium-treated plate, 1919 experiment 129
44.—Times at which failures reached 20 per cent in enameled cans of the regular and titanium-treated plate, 1919 experiment 131
45.—Service value of cans made from regular experimental plate and from titanium-treated plate, 1917 experiment, average of all heats 132
46.—Service value of enameled cans made from different lots of experimental plate, 1919 experiment 133

TABLE. PAGE

47.—Service value of cans of Bessemer, open-hearth, regular and titanium-treated plate, 1917 experiment 134
48.—Service value of coke and charcoal-coated plate of the 1917 experiment as determined from averages for all products in enameled cans 137
49.—Service value of enameled cans from different heats of the 1919 plate 138
50.—Average weight, in pounds per base box, of tin coating on different lots of commercial plate 139
51.—Time required for heat, and kind and quantity of materials in furnace charge and furnace additions, 1917 and 1919 experiments . . . . . facing 176
52.—Record of additions and tests, open-hearth furnace operation, 1917 experiment 177
53.—Record of additions and tests, open-hearth furnace operation, 1919 experiment 180
54.—Kind and quantity of ladle additions, record of pouring of ingots, additions for special ingots, number and weight of ingots, etc., 1917 and 1919 experiments . . . . . facing 180
55.—Analyses of final slags from ladles, 1917 experiment 181
56.—Time ingots were in mold, time between stripping and heating, and time in soaking pits, weight of ingots, and notes on rolling, 1917 and 1919 experiments 182
57.—Appearance of ingots of 1919 experiment when stripped 183
58.—Weight of front crop, other scrap, samples, and good bars from each ingot of 1917 experiment 183
59.—Carbon, manganese, phosphorus, sulphur, and copper content of sheet-bar samples, 1917 experiment 184
60.—Carbon, manganese, phosphorus, sulphur, copper, silicon and titanium content of sheet-bar samples, 1919 experiment 186
61.—Manganese and phosphorus losses, 1919 experiment 188
62.—Results of transverse tensile tests, 1917 experiment 190
63.—Results of lengthwise tensile tests, 1917 experiment 192
64.—Results of transverse tensile tests, 1919 experiment 194
65.—Results of impact-shear tests, 1917 experiment 197
66.—Results of notched-bar impact tests, 1919 experiment 198
67.—Results of alternating-impact tests, 1917 experiment 200
68.—Results of alternating-impact tests, 1919 experiment 201
69.—Results of hardness tests, 1917 experiment 203
70.—Loss in weight by atmospheric corrosion of samples from sheet bars of each type of steel, 1919 experiment 205
71.—Loss in weight by atmospheric corrosion of samples from copper-bearing and non-copper-bearing sheet bars, 1919 experiment 206
72.—Slag and sulphide inclusions, macrostructure, pearlite distribution, and grain size as shown by microscopic examination of polished sections of sheet bars, 1917 and 1919 experiments 208
73.—Losses in opening and time required for opening rolled sheets, 1917 and 1919 experiments 212
74.—Temperatures of black annealing, 1917 experiment 214
75.—Temperatures of black annealing, 1919 experiment 216

TABLE. PAGE

76.—Carbon content of sheets after black annealing, 1917 experiment..... 218
77.—Time required for opening after black annealing, losses in opening and losses in cold rolling, 1917 experiment..... 219
78.—Temperatures of white annealing, 1917 experiment..... 220
79.—Temperatures of white annealing, 1919 experiment..... 222
80.—Speed of operation and period of immersion in tinning, 1917 experiment 224
81.—Number of primes, wasters, and menders in various lots of tin plate, 1917 and 1919 experiments..... 225
82.—Number of wasters due to specified causes in various lots of tin plate, 1917 and 1919 experiments..... 226
83.—Carbon, manganese, phosphorus and sulphur content of steel from perforated cans of 1917 experimental pack..... 239
84.—Description of commercial tin plate used in 1917 experiment..... 247
85.—Copper content of commercial plate used in 1917 experiment..... 247
86.—Weight of tin coating on individual cans of 1919 experimental plate..... 248
87.—Phosphorus content of representative cans of 1919 experimental plate... 250
88.—Results of Erichsen test of tin plate, 1919 experiment..... 252
89.—Results of bending tests of tin plate, 1919 experiment..... 254
90.—Character of steel as shown by microscopic examination for slag inclusions, of unetched sections of cans from 1917 experiment..... 255
91.—Character of steel as shown by microscopic examination of etched sections of cans from 1917 experiment..... 256
92.—Character of steel as shown by microscopic examination of sections cut near perforations in miscellaneous cans from 1917 experiment..... 257
93.—Character of steel as shown by microscopic examination of representative samples of tin plate before and after etching, 1919 experiment.. 258
94.—Results of gelatine test, 1917 experiment..... 260
95.—Rusting test; average final gradings May 28, 1918, of tin plate exposed December 2, 1917..... 261
96.—Rusting test; average final gradings May 28, 1918, of tin plate exposed March 22, 1918..... 261
97.—Rusting test; average final gradings October 24, 1918, of tin plate exposed July 26, 1918..... 262
98.—Relative rusting of 1917 tin plate with reference to type of steel base.... 262
99.—Relative rusting of 1917 tin plate with reference to weight of coating... 263
100.—Relative rusting of 1917 tin plate with reference to copper addition to steel..... 263
101.—Relative rusting of 1919 tin plate from different kinds of steel..... 263
102.—Percentage of springers, perforations, and total failures, at specified inspection dates, of cider, peaches, blueberries and black raspberries, packed in enameled cans: Average of all heats, regular 1919 experimental plate..... 268
103.—Percentage of springers, perforations, and total failures, at specified inspection dates, of cider, peaches, blueberries, and black raspberries, packed in enameled cans: Average of all types of 1919 experimental plate..... 269

TABLE. PAGE

104.—Percentage of springers, perforations, and total failures, at specified inspection dates: Average of cider, peaches, blueberries, and black raspberries packed in enameled cans, all types of 1919 experimental plate..... 269

105.—Percentage of failures, during specified periods, in cans of regular and of titanium-treated plate, 1917 experiment, average of all heats: Apples and cider..... 270

106.—Percentage of failures, during specified periods, in cans of regular and of titanium-treated plate, 1917 experiment, average of all heats: Blueberries..... 270

107.—Percentage of failures, during specified periods, in cans of regular and of titanium-treated plate, 1917 experiment, average of all heats: Strawberries..... 271

108.—Percentage of failures, during specified periods, in cans of regular and of titanium-treated plate, 1917 experiment, average of all heats: Average of all products..... 271

109.—Percentage of failures, during specified periods, in enameled cans of regular and of titanium-treated plate, 1919 experiment: Cider..... 272

110.—Percentage of failures, during specified periods, in enameled cans of regular and of titanium-treated plate, 1919 experiment: Blueberries..... 273

111.—Percentage of failures, during specified periods, in enameled cans of regular and of titanium-treated plate, 1919 experiment: Peaches..... 274

112.—Percentage of failures, during specified periods, in enameled cans of regular and of titanium-treated plate, 1919 experiment: Black raspberries... 275

113.—Percentage of failures, at specified dates in enameled cans of regular and of titanium-treated plate, 1919 experiment: Average of all products..... 276

114.—Percentage of failures, at specified dates, in cans of silicon-treated regular and titanium plate, 1919 experiment, average of all products..... 277

115.—Percentage of failures, during specified periods, in cans of all heats of experimental and all lots of commercial plate, 1917 experiment, average of all products..... 278

116.—Percentage of failures, at specified dates, in cans of silicon-treated and non-silicon-treated plate, 1919 experiment, average of all heats, all types of plate, and all products..... 279

117.—Percentage of failures, during specified periods, in enameled cans of quarter-ingot lots of regular and titanium-treated plate with different weights of tin coating, 1917 experiment, average of all products..... 280

118.—Percentage of failures, during specified periods, in enameled cans of each heat of 1917 experimental plate, average of all products..... 281

119.—Percentage of failures, at specified dates in enameled cans of each heat of 1919 experimental plate, average of all products..... 282

120.—Percentage of failures, during specified periods, in enameled cans of each lot of commercial plate, 1917 experiment, average of all products.... 283

121.—Percentage of failures, at specified dates, in cans of apples packed in each type of plate, November 13, 1917..... 284

TABLE. PAGE
122.—Percentage of failures, at specified dates, in cans of cider packed in each type of plate, November 12, 1917 286
123.—Percentage of failures, at specified dates, in cans of blueberries packed in each type of plate, August 15, 1918 290
124.—Percentage of failures, at specified dates, in cans of strawberries packed in each type of plate, June 21, 1918 294

ILLUSTRATIONS

FIG. PAGE
1.—Locations of test specimens in steel-plate samples 43
2–6.—Typical views of sulphide inclusions in sheet bars illustrating various classes into which microsections were placed, according to amount and distribution of sulphides found in them 60
7–11.—Typical views of slag inclusions in sheet bars illustrating various classes into which microsections were placed, according to the amount of slag found in them 61
12.—Slag inclusions typical of the sheet-bar samples from the silicon-treated ingots of the 1919 experiment, unetched and magnified 150 diameters 65
13.—Typical microsections from sheet bars of the 1917 experiment, enlarged 3 diameters, illustrating the classification in regard to macrostructure after etching 65
14–17.—Typical views of microstructure of sheet bars from the 1917 experiment, illustrating the classification in regard to carbon distribution. 68
18–21.—Typical views of microstructure of sheet bars from the 1917 experiment, illustrating the classification in regard to grain size, all showing uniform carbon distribution 69
22.—Typical annealing curves, 1917 experiment, black annealing 76
23.—Typical annealing curves, 1919 experiment, black annealing 76
24.—Section of hot-rolled sheet from ingot R21, 1919 experiment, parallel to direction of rolling, etched with nitric acid and magnified 200 diameters, showing great distortion of grains 77
25.—Same as Figure 24 except perpendicular to direction of rolling, showing less distortion 77
26.—Section of same sheet as Figure 24 after black annealing cut parallel to direction of hot rolling, etched with nitric acid and magnified 200 diameters, showing ferrite grains not distorted, but carbides fine and arranged in lines 77
27.—Same as Figure 26 except perpendicular to direction of hot rolling 78
28.—Piece of same sheet as Figure 26 annealed in laboratory at a higher temperature, etched with nitric acid and magnified 200 diameters, showing the carbides segregated or massive between the ferrite grains 78
29.—Section of finished sheet from ingot CR3, 1917 experiment, etched with nitric acid and magnified 200 diameters, illustrating the coarse structure, with massive cementite and phosphorus markings, produced by the hotter annealing given to these sheets as compared with the practice in the 1919 experiment 78

FIG. PAGE
30.—Typical annealing curves, 1917 experiment, white annealing 80
31.—Typical annealing curves, 1919 experiment, white annealing 80
32.—Bending clamps in use with a bend partly completed 97
33.—Microstructure of cross-section of plate from an R2AN can from the 1917 experiment, etched with nitric acid and magnified 200 diameters, showing pearlite segregated at edges with center free from carbon 101
34.—Microstructure of cross-section of plate from an R2XNN can from the 1917 experiment, etched with nitric acid and magnified 200 diameters, showing pearlite segregated at edges, with massive cementite between the central ferrite grains 101
35.—Microstructure of cross-section of plate from a CR3AN can from the 1917 experiment, etched with nitric acid and magnified 200 diameters, showing very coarse ferrite grains with phosphorus markings, and massive cementite between them 102
36.—Microstructure of cross-section of plate from an H3AN can, etched with nitric acid and magnified 200 diameters, showing small ferrite grains and granular cementite in well distributed small particles. 102
37.—Microstructure of cross-section of plate from an H4XNN can, etched with nitric acid and magnified 200 diameters, showing large ferrite grains, with massive cementite and pearlite near edges, and carbon-free center 103
38.—Microstructure of cross-section of plate from a CB3XN can, etched with nitric acid and magnified 200 diameters, showing medium ferrite grains with phosphorus markings, massive cementite, and slag inclusions 103
39.—Edge of a perforation in plate from a CR2AN can, 1917 experiment, unetched and magnified 200 diameters, showing traces of light gray slag in the steel near the black corroded spots 104
40.—Corroded spots in plate from a CR2AN can, 1917 experiment, etched with nitric acid and magnified 200 diameters, showing slag inclusions near rust at upper edge 104
41.—Beginning of a corroded spot at a massive cementite particle close to upper surface of plate from a CR2AN can, 1917 experiment, etched with nitric acid and magnified 200 diameters 105
42.—Corroded spots associated with thin slag or sulphide inclusions in plate from a CR2ANN can, 1917 experiment, unetched and magnified 200 diameters 105
43.—Corroded streak or crack running lengthwise through a pearlite streak near (upper) surface of plate from a AT4AN can with carbon-free center, etched with nitric acid and magnified 200 diameters 106
44.—View of plate from a T6AN can not far from perforation, etched with nitric acid and magnified 200 diameters, showing no corrosion associated with the large slag inclusion in center of section 106
45.—Edge of T23 tin plate from 1919 experiment, unetched and magnified 400 diameters, showing smooth steel surface and even tin coating 107

FIG. PAGE

46.—Edge of SR22 tin plate, unetched and magnified 400 diameters, showing rough and pitted steel surface with depressions in it filled with tin... 107
47.—Microstructure of SCR21 tin plate, etched with nitric acid and magnified 400 diameters, showing segregated or massive carbides at the large grain boundaries, and black silicate inclusions..... 107
48.—Microstructure of SR23 tin plate from 1919 experiment, etched with nitric acid and magnified 400 diameters, showing typical fine carbide specks in the elongated ferrite grains..... 108
49.—Surface of SR24 waster sheet with numerous small blisters, enlarged 1.5 diameters..... 108
50.—Section through sheet shown in Figure 49, unetched and magnified 200 diameters, showing very rough steel surface, with tin filling the small pits..... 109
51.—Section through sheet shown in Figure 49, etched with nitric acid and magnified 200 diameters, showing an elongated thin slag streak..... 109
52.—Surface of ST22 waster sheet, enlarged 1.3 diameters, showing large blisters at bottom and pits called "seam in steel" at top..... 110
53.—Section through large blister shown in Figure 52, unetched and magnified 200 diameters, showing very long thin streak of slag in middle of plate 111
54.—Section through "seam in steel" shown in Figure 52, etched with nitric acid and magnified 200 diameters, showing very large oxide inclusion, with ferrite crystals distorted around it..... 111
55.—Results from gelatine test on coke plate..... 113
56.—Results from gelatine test on charcoal plate..... 113
57.—Relation between weight of coating and amount of rust on each sheet.. 116
58.—Section of plate showing three rust pits extending down into plate; magnification 200 diameters; coating not shown..... 118
59.—Section of plate showing a rust pit and a slag inclusion; magnification 400 diameters..... 118
60.—Relation of total failures to perforations, 1919 regular experimental plate; average of all heats, enameled cans..... 140
61.—Relation of total failures to perforations, 1919 experimental plate; average of all plate, enameled cans..... 141
62.—Relation of total failures to perforations, 1919 experimental plate; average of all products in all types of plate, enameled cans..... 141
63.—Effect of use of titanium; apples in plain cans, average of all heats, 1917 experimental plate..... 142
64.—Effect of use of titanium; cider in plain cans, average of all heats, 1917 experimental plate..... 142
65.—Effect of use of titanium; blueberries in plain cans, average of all heats, 1917 experimental plate..... 143
66.—Effect of use of titanium; strawberries in plain cans, average of all heats, 1917 experimental plate..... 143
67.—Effect of use of titanium; average of all products in plain cans, average of all heats, 1917 experimental plate..... 144

FIG. PAGE

68.—Effect of use of titanium; cider in enameled cans, average of all heats, 1917 experimental plate 144
69.—Effect of use of titanium; blueberries in enameled cans, average of all heats, 1917 experimental plate 145
70.—Effect of use of titanium; strawberries in enameled cans, average of all heats, 1917 experimental plate 145
71.—Effect of use of titanium; average of all products in enameled cans, average of all heats, 1917 experimental plate 146
72.—Effect of use of titanium; cider in enameled cans, heat 21, 1919 experimental plate 146
73.—Effect of use of titanium; cider in enameled cans, heat 22, 1919 experimental plate 147
74.—Effect of use of titanium; cider in enameled cans, heat 23, 1919 experimental plate 147
75.—Effect of use of titanium; cider in enameled cans, heat 24, 1919 experimental plate 148
76.—Effect of use of titanium; cider in enameled cans, average of all heats, 1919 experimental plate 148
77.—Effect of use of titanium; blueberries in enameled cans, heat 21, 1919 experimental plate 149
78.—Effect of use of titanium; blueberries in enameled cans, heat 22, 1919 experimental plate 149
79.—Effect of use of titanium; blueberries in enameled cans, heat 23, 1919 experimental plate 150
80.—Effect of use of titanium; blueberries in enameled cans, heat 24, 1919 experimental plate 150
81.—Effect of use of titanium; blueberries in enameled cans, average of all heats, 1919 experimental plate 151
82.—Effect of use of titanium; peaches in enameled cans, heat 21, 1919 experimental plate 151
83.—Effect of use of titanium; peaches in enameled cans, heat 22, 1919 experimental plate 152
84.—Effect of use of titanium; peaches in enameled cans, heat 23, 1919 experimental plate 152
85.—Effect of use of titanium; peaches in enameled cans, heat 24, 1919 experimental plate 153
86.—Effect of use of titanium; peaches in enameled cans, average of all heats, 1919 experimental plate 153
87.—Effect of use of titanium; black raspberries in enameled cans, heat 21, 1919 experimental plate 154
88.—Effect of use of titanium; black raspberries in enameled cans, heat 22, 1919 experimental plate 154
89.—Effect of use of titanium; black raspberries in enameled cans, heat 23, 1919 experimental plate 155
90.—Effect of use of titanium; black raspberries in enameled cans, heat 24, 1919 experimental plate 155

FIG. PAGE

91.—Effect of use of titanium; black raspberries in enameled cans, average of all heats, 1919 experimental plate. 156
92.—Effect of use of titanium; average of cider, blueberries, peaches, and black raspberries in enameled cans, heat 21, 1919 experimental plate 156
93.—Effect of use of titanium; average of cider, blueberries, peaches, and black raspberries in enameled cans, heat 22, 1919 experimental plate 157
94.—Effect of use of titanium; average of cider, blueberries, peaches, and black raspberries, in enameled cans, heat 23, 1919 experimental plate 157
95.—Effect of use of titanium; average of cider, blueberries, peaches and black raspberries, in enameled cans, heat 24, 1919 experimental plate 158
96.—Effect of use of titanium; average of cider, blueberries, peaches and black raspberries in enameled cans, average of all heats, 1919 experimental plate. 158
97.—Effect of use of titanium, silicon-treated plate; average of cider, blueberries, peaches and black raspberries in enameled cans, heat 21, 1919 experimental plate. 159
98.—Effect of use of titanium, silicon-treated plate; average of cider, blueberries, peaches and black raspberries in enameled cans, heat 22, 1919 experimental plate. 159
99.—Effect of use of titanium, silicon-treated plate; average of cider, blueberries, peaches and black raspberries in enameled cans, heat 23, 1919 experimental plate. 160
100.—Effect of use of titanium, silicon-treated plate; average of cider, blueberries, peaches and black raspberries in enameled cans, heat 24, 1919 experimental plate. 160
101.—Effect of use of titanium, silicon-treated plate; average of cider, blueberries, peaches and black raspberries in enameled cans, average of all heats, 1919 experimental plate. 161
102.—Curves illustrating method of calculating percentage service value. . . . 161
103.—Comparison of experimental plate with commercial plate; average of all products in plain cans, coke coating. 162
104.—Comparison of experimental plate with commercial plate; average of all products in plain cans, charcoal coating. 162
105.—Comparison of experimental plate with commercial plate; average of all products in enameled cans, coke coating. 163
106.—Comparison of experimental plate with commercial plate; average of all products in enameled cans, charcoal coating. 163
107.—Effect of use of copper; cider in enameled cans of coke coated regular plate of the 1917 experiment. 164
108.—Effect of use of copper; strawberries in enameled cans of coke-coated titanium-treated plate of the 1917 experiment. 164
109.—Effect of use of silicon in the mold as a deoxidizer; comparison of silicon-treated regular and copper-bearing plate with non-silicon-treated, average of all heats of all products in enameled cans. 165
110.—Effect of use of silicon in the mold as a deoxidizer; comparison of silicon-treated titanium and copper-titanium plate with non-silicon-treated, average of all heats of all products in enameled cans. 165

FIG. PAGE
111.—Effect of weight of coating; average of all products in enameled cans, of heat 3, regular plate 166
112.—Effect of weight of coating; average of all products in enameled cans, of heat 4, titanium plate 16
113.—Comparison of the seven heats of the 1917 experimental regular plate; average of all products in enameled cans, coke coating 167
114.—Comparison of the seven heats of the 1917 experimental regular plate; average of all products in enameled cans, charcoal coating 167
115.—Comparison of the seven heats of the 1917 experimental titanium-treated plate; average of all products in enameled cans, coke coating 168
116.—Comparison of the seven heats of the 1917 experimental titanium-treated plate; average of all products in enameled cans, charcoal coating 168
117.—Comparison of the four regular heats, 1919 experimental plate; average of all products in enameled cans 169
118.—Comparison of the four titanium-treated heats, 1919 experimental plate; average of all products in enameled cans 169
119.—Comparison of the four copper-bearing regular heats, 1919 experimental plate; average of all products in enameled cans 170
120.—Comparison of the four copper-titanium heats, 1919 experimental plate; average of all products in enameled cans 170
121.—Comparison of the different lots of commercial Bessemer plate of the 1917 experiment; average of all products in enameled cans 171
122.—Comparison of the different lots of commercial copper-bearing Bessemer plate of the 1917 experiment; average of all products in enameled cans 171
123.—Comparison of the different lots of commercial open-hearth plate of the 1917 experiment; average of all products in enameled cans 172
124.—Comparison of the different lots of commercial copper-bearing open-hearth plate of the 1917 experiment; average of all products in enameled cans 172
125.—Arrangement of lots of sheets in the annealing furnaces 213
126.—Illustration of warehouse record and method of recording failures ... 267

Canned Food Containers

INTRODUCTION

The relation of the quality of tin plate to the service value of cans for food products has been discussed for many years. Different factors have been held responsible for troubles experienced by canners, and a large amount of experimental work has been done by individual canners and can manufacturers. As a result of discussion in regard to the effect of the amount of tin coating on tin plate, a committee representing the National Canners Association, the American Sheet and Tin Plate Company, and the American Can Company, with assistance from the Bureau of Chemistry of the United States Department of Agriculture, in 1915–17 investigated the effect of weight of tin coating on the value of tin plate for food containers. This committee found that for most uses the value of the tin plate was practically the same with weights of coating of from one to three pounds of tin per base box. This did not hold, however, for resistance to perforations.

Only four packs were put up to test the effect of perforations and three of these produced an insignificant number of perforations. Only three perforations were found in 4,704 cans of apples packed half in Michigan and half in New York, and 31 were found in 1,176 cans of cider.

The relation of the weight of coating to perforations in 402 cans of Pennsylvania apples is shown by the following statement of the proportion of the total number of perforations occurring in cans with different weights of coating:

Cans with a tin coating of—	*Per cent*
0.83 pound per base box	31.4
1.03 pounds per base box	23.1
1.19 pounds per base box	14.2
1.40 pounds per base box	11.4
1.70 pounds per base box	11.7
1.96 pounds per base box	6.5
2.94 pounds per base box	1.7

One pack of 1,658 cans of cider was included in this investigation. No data in regard to perforations were given in the report, as the number at the time of publication was very small. Further observation of this pack was made by the National Canners Association until

September 22, 1918, nearly three years after packing. At this time there was a total of 232 perforations and their distribution with respect to weight of coating was as follows:

Cans with a tin coating of—	*Per cent*
0.83 pound per base box	34.9
1.03 pounds per base box	25.0
1.19 pounds per base box	17.7
1.40 pounds per base box	14.8
1.70 pounds per base box	4.7
1.96 pounds per base box	2.2
2.94 pounds per base box	0.9

In 1917 a second committee was formed to investigate the effect of various treatments of the steel of tin plate on its resistance to perforation by acid products. The original members of the committee were: H. A. Baker and W. S. Sellars, of the American Can Company; W. D. Collins, of the Bureau of Chemistry; W. D. Bigelow and F. F. Fitzgerald, of the National Canners Association; G. A. White and G. F. Comstock, of the Titanium Alloy Manufacturing Company.

Valuable assistance in planning and executing the work was received at different times from C. O. Ball, J. E. Robinson and F. J. Dashner, of the American Can Company; W. F. Clarke, of the Bureau of Chemistry; P. J. Donk, Emma Reh, A. E. Stevenson and C. C. Williams, of the National Canners Association; C. W. Hathaway and W. E. Buck, of the National Enameling and Stamping Company; W. J. Evans and W. G. Wellings, of the Titanium Alloy Manufacturing Company. Owing to changes in location, some members of the original committee dropped the work for a time and returned to it, while others dropped out permanently. This report has been prepared chiefly by W. D. Bigelow, W. D. Collins, G. F. Comstock, F. F. Fitzgerald, and A. E. Stevenson.

The studies involved service tests with foods canned commercially in containers made of tin plate of known history from the charging of the open-hearth furnace for the steel base through the various steps till the plate was finished. Every step in the manufacture of the steel, tin plate and cans and in the packing of the foods was followed by the committee. For instance, in the manufacture of the steel for tin plate, materials used were weighed under the supervision of committee members, who made records of temperature, took samples for analysis, and throughout the work were present at every point where confusion of lots of material might occur. Except where some special procedure

is noted, all operations followed regular commercial practice and were carried out by the regular employees of the various plants. These general principles of operation cover the whole experiment and are not repeated in connection with the detailed description of the different steps of the experiments.

The investigation was primarily a study of the influence of titanium in the manufacture of steel as a base for tin plate for food containers. At the same time advantage was taken of this opportunity to study the effect of copper on the steel base and the effects of different weights of tin coating. The 1917 experiments seemed to indicate that, in general, steel from heats which rose the most in the mold gave poorer service than that from heats which rose less. In the 1919 experiment, therefore, silicon was added in some molds to prevent this rising.

The first experiment, started in the spring of 1917, involved the manufacture of steel with and without the use of titanium as a ladle addition, and with and without the addition of copper in the mold. It was intended to use a divided spout in tapping the furnace, but this was found to be impossible on account of lack of plant equipment, so seven heats were made without the use of titanium and seven with titanium. In three heats of each series copper was added to one ingot. Tin plate was made from each heat with coke and with charcoal coatings, and several lots of commercial plate of various kinds were added to the experimental material for comparison. Cans were made; apples, cider, strawberries, blueberries and catsup were packed in them, and the perforations and springers occurring during storage were noted. Corn and peas were also packed to determine whether differences in base plate influenced discoloration. Physical, chemical and metallographic tests were made on the materials at various stages. The results on perforations showed such large differences between individual heats, as compared with those between the kinds of steel used, that before definite conclusions could be drawn it was considered essential to make further tests in which the variable factor introduced by the use of different heats for the titanium-treated and non-treated steels would be eliminated.

In the spring of 1919 the second experiment was started. A divided spout was used so that the steel treated with titanium and that not treated might be as nearly as possible identical. It was not possible to divide the stream equally, therefore the additions of manganese and phosphorus, which were made in equal quantities to the two ladles, were not in exactly the same proportions in the two steels. Titanium

was added to one ladle of each heat. Four heats were divided as indicated. In both the regular and titanium halves of each heat three ingots were given additional treatment in the molds. Copper was added to one, silicon to a second, and both copper and silicon to the third. These, with one ingot receiving no addition in the mold, furnished the steel for the experimental tin plate. Only one weight of coating was used. Black raspberries, red raspberries, blueberries, peaches, cider and apples were packed in cans made from the experimental plate and the behavior of the cans in storage was studied.

The report of the committee presents, first, a summary of the results of the entire investigation; second, a record of the work done and results obtained in each phase of the investigation, from the making of the steel to the final inspection of the canned products; third, appendices giving the basic data. This method of presentation will thus enable those interested in the subject to follow the work and its results to whatever degree of detail they may desire.

SUMMARY

The outstanding feature of the investigation is that no tin plate made from any heat of steel, regardless of the method of manufacture, chemical composition, or weight of coating, gave service indicating a satisfactory solution of the problem of perforations. Within the limits of these experiments the following specific conclusions, however, were reached concerning factors which influence the service value of tin plate.

SPECIFIC CONCLUSIONS

1. The use of titanium as a ladle addition in the manufacture of steel increases the resistance of tin plate to perforation.

2. Increased weight of coating increases the resistance of tin plate to perforation.

3. The results obtained with the use of copper do not offer any justification for the addition of copper to steel for the manufacture of tin plate, neither do they constitute a reason for specifying the absence of copper in such steels.

4. The use of silicon in the mold causes a large waste in the manufacture of tin plate and also reduces the resistance of the tin plate to perforations.

5. The resistance of tin plate to perforation is influenced to a greater or less extent by the furnace practice, by the chemical composition of the steel with special reference to the content and segregation of phosphorus and sulphur, and by other factors.

6. Discoloration of cans and contents is not influenced by variations in steel base or weight of tin coating. The factors which control the resistance of tin plate to perforation appear to have no relation to the discoloration of cans and contents.

GENERAL CONCLUSIONS

The resistance of tin plate to perforation depends upon so many factors, some of which are entirely unknown, that it is impossible to predict the service value of any can or lot of plate, even though complete data on the steel and coating may be available.

Although increased weight of coating on a sheet of steel will give increased service value over that which would be obtained with coke coating on the same sheet, and although titanium treatment of a single heat of steel will give a product having greater resistance to perforation

than the same heat of steel not so treated; nevertheless, a tin plate made from one steel with a light coating may offer greater resistance to perforation than a tin plate made from another steel with a heavier coating. Likewise, a heat of steel treated with titanium may give lower service value than another heat not so treated. This is illustrated in the experiments by the fact that the commercial open-hearth and Bessemer plate purchased on the open market gave better service value than any of the experimental plate manufactured. This can not be taken as an exception to the statement that titanium treatment improves the quality of steel. At the same time, the example shows that the use of increased weight of coating or the titanium treatment of the steel does not of itself insure the delivery of a product of high service value. The same reasoning applies to other factors.

Although other factors have a deciding influence on the service value of tin plate, nevertheless tin plate made from titanium-treated steel will give a higher service value than tin plate of the same heat of steel without cleansing treatment.

CORRELATION OF CAN SERVICE AND VARIABLES IN TIN PLATE MANUFACTURE.

Correlation by Heats.

Before drawing conclusions as to the influence, upon perforations in cans, of the principal factors investigated in these tests, such as titanium treatment, the presence of copper, or the weight of tin coating, it seemed advisable to study all the data on manufacture of steel and tin plate to see which, if any, of the minor variations in practice between different heats of steel had an important effect upon the can service.

The first step was a study of the service obtained with cans made from each heat and lot of steel. For this purpose reference was made to the tables of perforations, and especially to the curves showing the rate at which the perforations occurred. Great difficulty was found in expressing the relative can service of the different heats and lots in numerical terms. One method used for obtaining a numerical expression of can service was by means of planimeter measurements of the charts showing the average progress of failures (perforations and springers) for each heat with all products. The method of making this determination is explained more in detail in a later section of the report dealing especially with the perforation charts.

The figures for service value are obtained by calculations based on storage of total packs for from 20 to 24 months after packing, which

is commercially impracticable with perforating fruits. They give a value for the final total service at the end of the observation period without reference to the rate at which this service is rendered, and from a practical standpoint the latter consideration is important. The storage period was lengthened in order to increase the differences between the various lots of cans and to eliminate accidental differences due to factors other than those under consideration. Under ordinary commercial conditions the shipping of the product begins within a few days after packing and a considerable percentage of the product is consumed within the first few months. Such cans as are consumed or pass beyond the packer's guaranty give the packer 100 per cent service. A large proportion of the cans which perforated under the conditions of this experiment would have given 100 per cent service under commercial conditions, because they would have been consumed or passed beyond the packer's guaranty long before they perforated.

These considerations make it evident that the figures for can service used to show the relative values of the different lots of cans have no definite numerical relation to the actual value of the various kinds of plate for containers for fruits that will be consumed within the normal period.

As an illustration of the different values for can service that may be arrived at under varying rates of consumption of the canned products, Table 1 is presented. The service values of four kinds of tin plate made in the 1917 experiment are given, results from all heats and with all products in enameled cans being averaged together. The consumption of the cans is assumed to start in every instance at the date of packing, and to proceed uniformly to completion in 5½ months, 7½ months, 12½ months, and 19½ months respectively.

TABLE 1.—SERVICE VALUES OF TIN PLATE OF 1917 EXPERIMENT UNDER VARIOUS CONDITIONS.

Period of consumption after date of packing.	Cans not perforated.			
	Regular coke.	Titanium coke.	Regular charcoal.	Titanium charcoal.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
5.5 months....	95.9	98.3	98.3	99.0
7.5 months....	87.6	91.5	93.8	95.3
12.5 months....	65.3	72.2	75.9	81.0
19.5 months....	45.4	52.2	55.6	62.6

The values for can service that were used in the correlations below correspond approximately to the values here tabulated for the 19.5 months' period of consumption. It may be noted that whatever rate of consumption is assumed, the service values of the different kinds of plate are in the same order, but the variations between them increase as the rate of consumption becomes slower. This explains the general experience of the industry that when consumption is delayed loss from perforations is often serious, and the difference in service value between coke and charcoal coatings becomes important.

TABLE 2.—CORRELATION OF CAN SERVICE WITH OPEN-HEARTH FURNACE, LADLE, AND MOLD DATA.

Heat.	Can service.	Melting time.	Working time.	Pig iron and cast scrap in charge.	Time between furnace addition and tapping.		Time between last ladle addition and teeming first ingot.	Behavior of steel in molds.
					Last ore.	Silicon pig.		
1917	*Per cent.*	*H. M.*	*H. M.*	*Per cent.*	*H. M.*	*M.*	*M.*	
T1....	80	4 59	1 51	36.8	1 20	31	8	No rise.
T3....	70	6 3	2 21	40.3	1 40	31	8	Sank 6 in.
R5....	70	3 57	1 47	34.8	1 5	28	6	No rise.
T2....	69	3 42	1 41	34.8	1 15	26	10½	do.
R1....	65	3 55	2 29	33.8	1	31	7	do.
R3....	63	4 29	1 16	33.8	.. ..	18	5½	Sank few in.
T7....	55	5 39	1 53	42.3	1 42	19	10½	Sank 1 in.
T6....	50	4 21	1 52	33.6	1 13	17	8¾	Stationary.
T5....	48	4 21	1 18	37.0	42	22	7	Roseconsiderably.
T4....	47	5 55	2 30	39.8	37	13	9¼	Rose 2 in.
R7....	46	5 13	2 38	42.9	.. ..	23	5	Stationary.
R4....	45	3 55	2 31	34.3	32	16	7	do.
R6....	45	7 45	1 42	39.7	.. ..	20	4½	Rose 4 in.
R2....	40	4 48	2 10	37.0	48	14	6	Rose considerably
1919								
23....	84	.. ..	2 21	37.0	46	21	8½	Sank 0 to 1 in.
21....	81	.. ..	1 30	36.8	1 8	19	11	Sank 5 to 11 in.
22....	71	.. ..	2	36.2	1 6	24	9	Rose 0 to 1 in.
24....	69	.. ..	2 14	38.5	49	28	10	Rose 2 to 5 in.

Separate values for service were obtained for coke-coated and charcoal-coated plate in the 1917 experiment from the curves giving the rate at which perforation occurred, but for most of this work the two figures were averaged together to get a single figure for each heat. In the 1919 experiment the can service figures for copper-bearing and non-copper ingots were averaged together for correlation with the

open-hearth data, but for the other correlations only the non-copper ingots were considered. The silicon-treated steel was not included in this work at all. In the study of data from the sheet-bar tests, only the bars from the middle of the ingot were considered in the 1919 experiment, as the steel whose can service is studied came only from that part of the ingot in this experiment. In the 1917 experiment, where the part of the ingot from which the cans were made is not known, average data for the entire ingot were used in these correlations.

The first step in this work was the arrangement for each experiment of all the heats in the order of decreasing can service percentage. The open-hearth furnace data were studied first, then the data on ladle and mold practice, as presented in detail in Appendices II and III. Table 2 gives the arrangement of the heats, with certain data that seemed significant tabulated in the same order.

The charging time in the open-hearth furnace did not bear any relation to the can service, hence is not given in this table. The melting and working times, however, show that most of the shorter times are near the top of the list, among the heats that gave good can service. The items of the furnace charge and additions did not seem to show any effect.

The time allowed after the last ore addition in the furnace before tapping seems to have been a fairly important factor in the steel quality as shown by can service, for among those heats which received ore in the 1917 experiment, all in which this time was less than an hour showed can service below 50 per cent, and all in which it was an hour or more showed 50 per cent or better can service. In the 1919 experiment there is a marked exception to this rule, but in this instance the last ore addition was small. The time between the addition of the silicon pig and tapping seems also to have been a factor worthy of consideration in 1917, as in the five heats with best can service this time was longer than in any of the other heats. This deduction was not checked, however, in 1919.

A study of the time each heat was held in the ladle showed only a very slight indication that the longer times were better. The time of teeming an ingot, the temperature of the steel, and the slag analyses did not seem to bear any relation to the can service.

The behavior of the steel in the molds is probably one of the most important factors in can service, as well as in making good steel for any purpose. All the heats which rose in the molds, in both experiments, gave comparatively poor service, while all those that sank were better.

Most of those heats which were stationary or are marked "did not rise" were also good, although two of them gave poor service.[1]

Some interesting observations might be made at this point on the use of titanium in this steel. In the 1917 experiment the heats that received 2.5 pounds of ferro-carbon-titanium per ton were in general better than those that received 3 pounds per ton, yet in the 1919 experiment a larger amount of this alloy per ton gave a greater improvement of the titanium-treated steel over the regular, as shown by the following statement:

	Pounds of ferro-carbon-titanium used per ton.	*Difference in can service percentage between regular and titanium steel.*
Heat 24	5.0	14
Heat 21	2.3	10
Heat 22	1.8	10
Heat 23	1.9	7

These figures include the service values of the copper-bearing steel as given on page 133.

Differences in the cooling, heating, and rolling of the ingots appeared to have no influence on the can service, but a study of the sheet-bar properties showed some interesting correlations, as given in Table 3. An examination of the carbon and sulphur contents showed no relation to the can service in the 1917 experiment, though in the 1919 experiment the heats with higher contents of these elements gave worse can service than those with lower contents. The manganese content suggests a slight relation to the can service in both experiments, the lower figures, with some exceptions, being near the top of the column in Table 3, among the heats with the best can service percentage. The phosphorus content showed a more definite relation, all the heats with less than 0.075 per cent phosphorus having given 65 per cent or better can service in the 1917 experiment and 73 per cent or better in the 1919

[1] The behavior in the molds is governed by the escape of gases from the solidifying steel, and appears to be definitely related to the furnace practice or conditions. This is indicated by the correlation of the behavior in the molds with the time that each heat remained in the furnace after the last ore addition, and after the silicon pig addition. The effect of the behavior in the mold is shown to a certain extent by the laminations in the tensile fractures, the microscopic segregation, etc., as well as by the wasters due to steel defects and by the can service. In other words, the action in the molds appears to indicate in a general way the quality of the steel on the assumption, of course, that no killing agent like silicon is used.

TABLE 3.—CORRELATION OF CAN SERVICE WITH PROPERTIES OF STEEL IN SHEET BARS.

Heat.	Can service.	Average manganese content.	Average phosphorus content.	Tensile strength.[a]	Laminations in tensile fractures.	Average quality in regard to—			
						Sulphide inclusions.	Slag inclusions.	Macro-structure.	Pearlite distribution.
1917.	*Per cent.*	*Per cent.*	*Per cent.*						
T1.....	80	0.30	0.057	55,600	1.6	2.25	3.50	1.88	1.88
T3.....	70	.28	.070	53,600	2.0	3.12	3.12	2.12	2.25
R5.....	70	.23	.066	53,600	1.1	2.25	2.62	2.12	1.88
T2.....	69	.20	.067	55,400	2.0	3.12	3.12	1.75	1.75
R1.....	65	.27	.064	54,600	1.5	2.25	2.75	1.37	1.88
R3.....	63	.34	.077	60,400	1.0	2.62	2.75	.62	.75
T7.....	55	.29	.087	56,600	.9	3.00	2.88	1.62	1.37
T6.....	50	.31	.085	57,000	1.8	2.88	2.75	1.62	1.37
T5.....	48	.32	.099	61,600	1.0	2.00	2.50	1.00	.50
T4.....	47	.28	.097	61,000	1.7	2.88	2.62	1.00	1.25
R7.....	46	.35	.078	57,100	.9	3.00	3.00	1.75	1.75
R4.....	45	.28	.076	55,700	2.3	2.62	2.50	2.12	2.12
R6.....	45	.38	.086	57,300	1.4	1.75	2.50	1.00	1.00
R2.....	40	.29	.125	62,800	1.1	1.88	2.12	1.00	.75
1919.									
T21.....	88	.28	.043	51,200	None.	2.00	2.75	1.50	1.50
T23.....	84	.30	.069	56,100	do.	2.00	1.75	1.50	1.50
R21.....	78	.30	.042	53,600	do.	2.00	2.00	2.50	2.00
R23.....	75	.33	.070	55,800	Bad.	2.00	2.50	2.00	2.00
T22.....	73	.30	.070	57,200	None.	2.00	2.75	1.00	1.50
T24.....	73	.34	.090	59,700	Bad.	2.00	1.00	1.00	.50
R22.....	60	.37	.100	59,800	None.	1.00	1.75	.50	.00
R24.....	55	.32	.109	59,700	Bad.	1.00	2.00	.50	.50

[a] Average of lengthwise and transverse for 1917; for 1919, transverse only.

experiment, while all the heats with higher phosphorus than this gave worse can service in both experiments.

The tensile strength of the sheet bars shows that the heats of greater strength gave lower can service, with exceptions, but this is probably a reflection of chemical differences which exerted the same influence on the tensile strength as on the can service. For probably the same reason the heats which gave lowest results in the impact tests in the 1919 experiment were those with the lowest can service. The elongations in the tensile tests and the Landgraf-Turner alternating-impact results showed no relation to can service, neither did the occurrence of crystalline fractures in the tensile tests. There is no indication that the heats giving better can service showed fewer laminations in the tensile fractures in the 1917 experiment. In the 1919 experiment, however, as a rule the heats giving better can service showed fewer laminations in the fractures. The figures for laminations in the 1917 experiment were obtained in the same manner as those for slag inclusions, etc., by giving a bar with no laminations an arbitrary mark of 3, one with slight laminations a mark of 2, medium laminations 1, and bad 0. These marks were then averaged for each heat, and a higher mark, therefore, indicates fewer laminations.

The results of the microscopic examination of the sheet bars give some rather interesting indications when studied in connection with the can service. The column on sulphide inclusions in Table 3 was obtained by assigning numbers to the results of grading on the basis of distribution of sulphides, in the same way that the results on slag inclusions were reported. These numbers were then simply averaged for each heat, and a higher figure means a more uniform distribution of sulphides. The quality in regard to sulphide inclusions does not seem to be definitely related to the can service, although it was worst in the two heats of lowest service percentage in each experiment.

No definite relation appears between can service on the one hand and slag inclusions, distribution of pearlite, and macrostructure on the other, but the results in Table 3 show that many heats better in these respects gave the better can service, and many of those poorer in these respects gave poorer can service.

The various features of practice in the manufacture of the tin plate from the sheet bars did not show any significant correlations with the can service. In general, the best heats in regard to can service gave most trouble in opening of the sheets after rolling of the packs. This

was probably due to the lower phosphorus content of those heats. No correlation was apparent between the annealing temperatures and the can service. There was no relation between the difficulty in separating the sheets after black annealing and the can service value, the amount of sticking depending upon the temperature of annealing.

The percentage of total wasters among all the coke sheets of each heat in the 1917 experiment showed no relation to the can service, but in the experimental lots of coke plate, the highest steel waster percentages occurred, with exceptions, in the heats giving lowest can service. This is brought out in Table 4. It is shown there that with both coke and charcoal plate in the 1917 experiment, and also in the 1919 experiment when only coke plate was made, the heats which gave the larger percentages of wasters due to steel defects were among those showing poor can service.

In the 1919 experiment Erichsen tests and bending tests were made on the tin plate, but their results do not show any relation to the can service. The microscopic examination of this tin plate, however, showed in general that there were more prominent sulphide inclusions and "high-phosphorus" bands in the heats that gave poor service than in the better heats. No relation appeared between the results of the rusting test or the gelatine test and the resistance of the plate to perforation, except in so far as the tests and the resistance to perforations are affected by weight of coating. Heavier tin coating gave better results in general in all these tests without regard to the steel base (see also page 116).

The chemical analyses of the tin plate from failed cans showed more definite relations to the can service. All of these analyses, except those on copper-bearing steel and on the quarter-ingot lots of R3 and T4, were averaged together for each heat to give the values in Table 4. It is seen here that the heats in which the cans show highest carbon in the 1917 experiment are near the bottom of the can service list, with some exceptions. The same is true of the manganese and, to a very slight degree, of the phosphorus in the 1917 experiment. The sulphur content, however, shows no relation to the can service. The phosphorus content in the 1919 experiment shows a more consistent relation to the can service, as the average for each heat increases almost without exception as the service percentage becomes lower.

By comparing the average phosphorus and sulphur content of the failed cans of the 1917 experiment as given in Table 32 with the

TABLE 4.—CORRELATION OF CAN SERVICE WITH RESULTS OF INSPECTION AND ANALYSIS OF TIN PLATE.
1917 EXPERIMENT.

Experimental coke plate.				Experimental charcoal plate.			Experimental coke and charcoal plate averaged.						
		Wasters.							Average analyses of tin plate in perforated cans.				
Heat.	Can service.	Total.	Due to steel defects.	Heat.	Can service.	Wasters due to steel defects.	Heat.	Can service.	Carbon.	Manganese.	Phosphorus.	Sulphur.
	P.ct.	*P.ct.*	*P.ct.*		*P.ct.*	*P.ct.*		*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
T1.....	72	0.3	0.0	T1.....	87	0.8	T1.....	80	0.124	0.341	0.0659	0.0560
T3.....	65	9.1	3.9	T3.....	75	7.5	T3.....	70	.117	.306	.0912	.0523
R5.....	65	2.9	2.0	R5.....	74	2.8	R5.....	70	.112	.268	.1063	.0706
T2.....	64	5.1	3.6	T2.....	74	2.0	T2.....	69	.116	.284	.0805	.0618
R3.....	59	6.4	1.1	R1.....	74	1.4	R1.....	65	.117	.326	.0876	.0551
R1.....	56	3.7	1.1	R3.....	67	6.3	R3.....	63	.129	.357	.0937	.0494
T7.....	49	1.4	.9	T7.....	60	1.7	T7.....	55	.122	.306	.0946	.0424
T6.....	46	2.2	.6	T6.....	54	4.1	T6.....	50	.121	.336	.0919	.0576
T5.....	44	1.4	1.2	R7.....	53	3.4	T5.....	48	.129	.362	.1030	.0605
T4.....	44	7.8	5.7	T5.....	52	1.3	T4.....	47	.134	.334	.0975	.0518
R6.....	43	17.7	14.4	T4.....	50	10.2	R7.....	46	.127	.336	.0897	.0573
R4.....	41	12.3	10.6	R4.....	49	4.6	R4.....	45	.126	.352	.0926	.0550
R7.....	39	1.6	1.3	R6.....	46	10.4	R6.....	45	.122	.371	.0904	.0624
R2.....	35	7.1	5.4	R2.....	44	10.3	R2.....	40	.135	.341	.1257	.0757

1919 EXPERIMENT.

Heat.	Can service.	Wasters.		Results of microscopic examination of tin plate.		Average phosphorus content of tin plate of representative cans.
		Total.	Due to steel defects.	Sulphide inclusions.	Phosphorus bands.	
	P.ct.	*P.ct.*	*P.ct.*			*Per cent.*
T21	88	5.7	.4	Very few	Distinct	0.041
T23	84	8.8	.5	Few	None	.065
R21	78	10.7	3.2	do	Slight	.055
R23	75	7.2	.4	Many	None	.068
T22	73	26.9	5.3	Few	Distinct	.069
T24	73	43.5	42.9	do	do	.078
R22	60	19.0	9.2	Many	do	.079
R24	55	32.1	10.3	Medium	do	.100

average sheet-bar analyses (Table 6) and ladle-test analyses (Table 5) of corresponding steels, it is noted that in every instance the failed cans of a given heat averaged higher in these elements than the sheet-bars or ladle test of the same heat. This is an interesting relation, as it shows that those cans which were made of the higher phosphorus and higher sulphur portions of the ingots had a tendency to perforate more quickly. The phosphorus determinations on cans of the 1919 experiment, which were representative rather than failed cans, gave, on the other hand, about the same results in general as the ladle test or sheet-bar analyses.

If high average phosphorus content should be avoided, uniform distribution of phosphorus in the ingot is equally important, as the average phosphorus content in the ingot is no indication of the relative percentage of phosphorus in different portions of the same ingot.

Practically equal distribution of phosphorus among all the sheets made from an ingot of steel can be accomplished in only two ways, namely, by killing[1] the steel so as to prevent all action in the mold, or by using only the lower half or less of the ingot. The first method is commercially practicable, but subject to more or less objection for this grade of steel because it generally involves more non-metallic inclusions in the metal, more cracking during rolling, and more surface defects on the sheets.

The second method is, of course, too wasteful to be considered. In these experiments neither of the methods was tried, except in the ingots of the 1919 experiment that were killed with silicon in the mold with unsatisfactory results. The manufacture of sheet bar by the most widely adopted and probably the best practice at the present time necessarily involves considerable segregation of phosphorus and sulphur, and therefore the individual sheets of tin plate, even from a single heat, are bound to differ materially in their content of these elements.

The above correlations refer to the experimental heats of steel. The comparison of the commercial lots of steel with the experimental heats will be given later.

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[1] There is a difference of opinion in the steel industry in regard to the relative value of effervescing and killed steel for tin plate manufacture. Our experiments have covered rather completely the use of titanium treatment in effervescing steel and have also included steel which was killed by the use of silicon in the mold. As in both instances the same general results of the use of titanium were found, we believe that any conclusions drawn from these experiments are equally applicable to effervescing and killed steel.

General Correlations

In considering the chief variables such as titanium treatment and copper additions, the fundamental differences between the two experiments must be kept in mind. In the 1917 experiment the regular and titanium-treated steels came from different heats, and the sheets used for making the cans came from unknown parts of the different ingots, thus introducing uncontrolled variables of considerable importance. In the 1919 experiment, on the other hand, titanium-treated, regular, copper-bearing, and silicon-treated steels were all made from each one of the four heats, and the sheets used for the cans came only from the central parts of the ingots. Therefore, for comparing regular and titanium-treated steel, the results of the 1919 experiment are the more valuable; for investigating the effect of copper, both are valuable. The 1919 experiment is the only one in which the effect of the use of silicon in the mold is shown. However, for comparing enameled with plain cans, and charcoal coating with coke coating, the results of the 1917 experiment must be used.

The results of these experiments confirm the experience of the industry in showing that the resistance to perforation of enameled cans is much less than that of plain cans.

Table 4 shows clearly that there is a definite relation between weight of tin coating and resistance to perforations. In all of the experimental heats there is not a single instance where increased can service was not obtained with charcoal coating over that obtained with coke coating. This increased service not only applies for the average of all products with the same heat as is shown in Table 4, but also with few exceptions for each product with each heat, as may be seen by consulting Figures 64–72 and Tables 105–108. This agrees with previous experimental work on the relative value of different weights of tin coating for canned-food containers.

Silicon used as a final addition in the mold was found to be detrimental both in regard to blistered sheets, which caused wasters at the mill, and in regard to rapidity of perforation of cans packed with cider, peaches, blueberries and raspberries. There were a few exceptions to this general statement. It must be borne in mind, however, that in these experiments silicon was used only in the molds.

The experimental plate used in both the 1917 and 1919 experiments included both copper-bearing and non-copper-bearing steel. The non-copper-bearing steel contained from 0.05 to 0.1 per cent copper as a normal constituent. The copper-bearing steel contained from 0.3 to

0.62 per cent. The resistance of these steels to perforation varied so much with different fruits and even with the same fruit that no general conclusion can be drawn as to the influence of copper additions in preventing perforations. The experiment did not include copper-free steel, inasmuch as its commercial manufacture is impracticable on account of the copper content of commercial scrap; neither did it include steels of relatively high copper content (1.0 to 1.5 per cent).[1]

Titanium treatment of steel gave plate offering more resistance to perforation of cans by the fruits packed in these experiments than plate from the same steel not treated with titanium. In both experiments and with every fruit the average service from plate of the titanium-treated steel was higher than that from the regular steel, with one exception in charcoal-coated enameled cans, where there was little difference. Furthermore, in each heat of the 1919 experiment the titanium-treated portion gave better service than the regular portion. These two portions were made as nearly identical as possible, except for the titanium addition to one of them, and the same relation occurring in every one of the four heats is a definite indication of the effect of titanium. It is true that in some of these heats the phosphorus and manganese contents were higher in the regular than in the treated portions, but in at least one of them the chemical compositions of the two portions were practically identical, yet the treated portion of that heat gave better can service than the regular portion, just as in the other heats.

Another point brought out by this work is that the titanium-treated steel gave increased production of good material at the mill over that obtained with the regular plate. The yield of good sheet bars from the ingots was larger, and the percentage of waster sheets of tin plate caused by steel defects was smaller, for the titanium-treated steel than for the regular.

A detailed correlation of can service with the variations of practice in the manufacture of the individual lots of commercial open-hearth and Bessemer plate, similar to the discussion given of these variations between the experimental heats, is impossible because the histories of the commercial lots are not known. Comparisons between the commercial and experimental plate in regard to resistance to rusting, chemical composition and metallographic structure may, however, be correlated with the comparison between them on the basis of can service. It has

[1] The study of the latter would be interesting provided their physical properties are suitable for tin plate manufacture.

been shown that the commercial plate gave, in general, better can service than the experimental.

Since the commercial plate rusted much faster than the experimental, it is evident that the resistance to rusting bore no relation to the can service. In the gelatine test, on the other hand, the commercial plate appeared better, although the difference was largely confined to the coke coatings. This must not be taken as evidence of the value of the gelatine test for determining can service, however, for in this test the coke and charcoal commercial plate averaged practically alike, while in the cans the charcoal coatings gave, in general, decidedly better service. There was a greater difference in weight of coating between the commercial coke and charcoal plate than between the similar kinds of experimental plate.

The metallographic work indicated that the commercial plate, especially that made by the Bessemer process, contained more slag inclusions than the experimental, so that its good can service shows that other factors must be of more importance in this connection than the inclusions in the steel. The microstructure of the commercial plate varied greatly, but at least some of it had a finer structure than the experimental. Sufficient data are not available from this work, however, to warrant the conclusion that this was a determining factor in its superiority in can service over the experimental plate.

The chemical analyses showed that the commercial plate averaged decidedly higher in manganese than the experimental, and also somewhat higher in phosphorus and sulphur, and lower in carbon. Its better can service than that of the experimental plate does not therefore agree with what would be expected, considering the conclusions as to the effect of these impurities in the experimental steel. This shows that the amount of manganese, phosphorus, and sulphur in a steel is not a criterion of its service value. Certainly, conclusions with reference to service value drawn from such data are only warranted with steels manufactured under identical conditions.

No conclusions could be drawn from the commercial plate regarding the effect of copper additions, since too much of the so-called copper-bearing plate was found to be actually free from copper. Thus the conclusion, drawn from the study of the experimental plate, that the addition of copper had no consistent effect on the can service, was not affected by any results from the commercial plate.

PRODUCTION AND TESTING OF SHEET BARS

The steel was made in fifty-ton basic open-hearth furnaces, in which oil was used for fuel.

The raw materials for both experiments were taken from regular stock with no special selection. About 40,000 or 50,000 pounds of cold pig iron and an approximately equal quantity of miscellaneous scrap were used with enough cast scrap, turnings and mill scrap to make a charge of about 140,000 pounds of metal. Notes in regard to the composition of these materials and also of the ore, lime, fluorspar, silicon pig, ferro-manganese, ferro-phosphorus and ferro-carbon-titanium are given in Appendix I.

FURNACE OPERATION

In both experiments the furnace operation followed the practice of the mill for the production of steel for tin plate. In 1917 W. J. Evans supervised the finishing of the heats, the regular melters agreeing with his judgment in every case. A special effort was made to secure uniform heats, because alternate heats were treated in the ladle with titanium and uniformity was necessary to permit proper comparison of regular and titanium steel.

In 1919 C. W. Hathaway supervised the finishing of the heats for the committee. Since a divided spout was used, similarity of the different heats was not so important as in 1917.

Charging of the furnace took about five hours; in about five hours more the working of the heat began and it took about two hours. Records of the charges are given in Appendix II, which also shows the quantities of ore, pig iron, and fluorspar added during the working of each heat, and the quantity of ferro-manganese and silicon pig added just before tapping, with the time at which each addition was made.

Throughout both experiments the steel not treated with titanium was called "regular" and designated by R and the titanium-treated steel was called "titanium" and designated T. In 1917 the fourteen heats from which ingots were taken were designated R1, R2, etc., and T1, T2, etc. Other letters were added to the designations to indicate treatment in the mold and other variables through the tinning and can manufacture. The four heats from which ingots were taken in 1919 were designated R21 to R24 and T21 to T24.

TREATMENT IN LADLE

In the 1917 experiment 12 pounds of 50 per cent ferro-silicon was added to each heat of steel in the ladle. In two of the heats ferro-manganese was added in the ladle. Action in the furnace always reduced the phosphorus too much, and ferro-phosphorus was added in the ladle to make the percentage of phosphorus in the steel sufficiently high to prevent sticking of the sheets during rolling. Most of the heats required from 500 to 600 pounds of ferro-phosphorus. In the 1917 experiment ferro-carbon-titanium was added in the ladle to alternate heats. From 150 to 200 pounds was added to each heat; this was about 2½ pounds per ton of steel.

In 1919 a divided spout was used and the heat was tapped into two ladles. A ladle stopper was arranged to dip in the stream of steel from the furnace to regulate the division between the two ladles. This regulation was not wholly successful and the heats were not divided evenly. To each ladle was added 250 pounds of ferro-manganese and 325 pounds of ferro-phosphorus. Since the two received different quantities of steel, the proportions of manganese and phosphorus were not the same for the two portions of any heat. This is brought out in the discussion of analyses of sheet-bar samples in Appendix VI. Seventy-five pounds of ferro-carbon-titanium was added to one ladle in each of the first three heats and 150 pounds was added to one ladle of the fourth heat. The latter was twice the normal quantity for a titanium-treated soft steel.

The times at which the various additions were made to the ladle and the quantities of the different materials added are shown in Appendix III. A few temperature measurements made with an optical pyrometer during the tapping of the furnace are given in Appendix II.

In the 1917 experiment the first ingot of each regular heat was poured within one or two minutes after the ladle was taken away from the furnace. The titanium steel was held in the ladle four or five minutes longer, in order to give time for action of the titanium. In the 1919 experiment both regular and titanium steels were held in the ladles eight to ten minutes after the ladle additions.

TREATMENT IN MOLDS

The inner dimensions of the ingot molds were: Bottom, 33½ by 15½ inches; top, 32½ by 14¾ inches; height, 61 inches. The molds for the ingots to be used in the experiments were placed at about the

middle of the string of molds, so as to take steel from near the middle of the ladle. In both experiments the ladle nozzle had a diameter of 2 inches and the time of pouring each ingot was generally from 40 to 60 seconds.

The first ingot taken for the experimental tin plate in 1917 was from the middle of the string of ingots, the seventh to the fifteenth, according to the size of the heat and the sizes of the molds. In the 1919 experiment the third ingot in a string was the first to be taken for the experiment. In both experiments the ladle test samples were taken during the pouring of the fourth ingot. Therefore, in the 1917 experiment the ladle sample was taken some time before the pouring of the ingot used for the experimental plate, and in 1919 during the pouring of one of the ingots so used.

In the 1917 experiment copper was added to one ingot in each of the first three heats of the regular and of the titanium steel. These ingots were designated as CR1, CR2, CR3 and CT1, CT2, CT3. The copper was in small pieces and was added slowly as the steel filled the mold. Steels with and without copper having the same number should be strictly comparable because they were from consecutive ingots of the same heat and therefore, except for copper, as nearly alike as could be obtained. On the other hand, ingots of the same number from the regular and titanium steels of the 1917 experiment were not equally comparable, inasmuch as they represent different heats of steel. It was believed that by using fourteen heats, seven of regular steel and seven of titanium-treated steel, the average results of the two would be comparable with each other and would eliminate individual differences due to the different furnace treatment.

No other additions were made to the steel except that in 1919 silicon was added to two ingots of the R and the T set in each of the four heats. Copper was added to one ingot without silicon and to one with silicon in each set. Copper was added in the 1919 experiment as the steel was poured, except in the first heat, where the copper was placed in the bottom of the mold. Silicon was added when the mold was nearly filled, except in the regular non-copper ingot of the second heat, where the silicon was added gradually during the filling of the mold.

In 1919 eight ingots were taken from each heat. Division of the heat into two ladles gave the regular and titanium-treated portions. The string of molds was divided, and the regular steel used for the first part of the string and the titanium-treated steel for the last part. Each section began with two large ingots. The third was R21 or T21;

copper was added to the fourth, giving CR21 and CT21; silicon was added to the fifth, giving SR21 and ST21; both silicon and copper were added to the sixth, giving SCR21 and SCT21. The ingots from heats 22, 23 and 24 were treated in the same way. There were 32 ingots taken for the experiment. Except for the slight differences due to the unequal division of the steel between the two ladles, ingots with the same heat number were strictly comparable. There is no necessary

TABLE 5.—CARBON, MANGANESE, PHOSPHORUS, SULPHUR, AND COPPER CONTENT OF STEEL AS SHOWN BY LADLE ANALYSIS, 1917 AND 1919 EXPERIMENTS.

Steel.	Carbon.	Manganese.	Phosphorus.	Sulphur.	Copper. [a]
1917 experiment.	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*
R1	0.11	0.30	0.070	0.044	0.048
R2	.15	.33	.106	.067	.....
R3	.14	.34	.071	.039	.....
R4	.12	.33	.076	.039	.....
R5	.19	.30	.070	.050	.053
R6	.14	.38	.073	.056	.....
R7	.13	.34	.075	.046	.....
T1	.15	.33	.050	.044	.053
T2	.11	.29	.063	.043	.....
T3	.10	.33	.062	.038	.....
T4	.13	.35	.079	.040	.....
T5	.15	.35	.090	.056	.068
T6	.12	.34	.067	.043	.....
T7	.10	.29	.074	.033	.....
1919 experiment.					
R21	.11	.30	.060	.033	.....
R22	.12	.35	.091	.043	.....
R23	.12	.36	.065	.045	.....
R24	.12	.31	.091	.051	.....
T21	.10	.25	.040	.035	.....
T22	.13	.29	.076	.040	.....
T23	.11	.32	.054	.042	.....
T24	.13	.26	.079	.053	.....

[a] Copper determination was made on sheet bars and for only R1, R5, T1 and T5.

relation between heats 21, 22, 23 and 24. R21 and T21 are, however, identical except for the titanium treatment and for any difference due to unequal division of the heat. The history of the two steels up to the ladle additions is the same. R21 and CR21, as well as SR21 and SCR21 and the other pairs of copper and non-copper ingots, are as nearly alike as possible except for copper, because they are consecutive ingots. R21 and SR21 and all the other similar pairs were separated by

only one ingot in the teeming, and these are comparable to show the effect of silicon. Details of the teeming are given in Appendix III.

In both experiments the steel effervesced freely in the molds, except in those ingots in which silicon was used. The change in level of the top of each ingot during effervescence was estimated and noted in the 1917 experiment, and was measured as carefully as possible in the 1919 experiment, since the quality of steel for certain purposes may be judged by this action in the molds. In the pouring of a few of the ingots in the 1919 experiment, the steel froze in the nozzle of the ladle and was burned out with oxygen so that pouring could continue. On account of the possibility of these ingots being contaminated by oxide, notes are given in Appendix IV, showing the ingots in which this occurred.

Table 5 gives the results of the analysis of the ladle test for all heats used in both experiments.

HEAT TREATMENT OF INGOTS

The special ingots chosen for making the tin plate to be tested were left to solidify and cool in the molds for about an hour and a half; details as to the periods are given in Appendix IV. After the molds were stripped from the ingots, the surfaces of the ingots were examined; notes on their condition are given in Appendix IV.

It took from about 5 to 20 minutes to charge the ingots into the soaking pits after stripping, except the ingots from heats R2 and T2 of the 1917 experiment, and those from the second heat of the 1919 experiment. The former were allowed to become entirely cold before reheating for rolling, and the latter stood about 48 minutes after being stripped before their heating commenced. The periods of heating before rolling were very irregular on account of fuel and draft conditions in the various soaking pits. The shortest period was 1¼ hours, and the longest 6¾ hours. Individual figures are tabulated in Appendix IV.

ROLLING

The ingots were rolled in a universal mill directly to plates, with a width of 29½ inches and a thickness of 7/16 inch. This constituted an important difference from ordinary practice in tin-plate manufacture, for usually the ingots are rolled first into blooms in a blooming mill, in which they are turned over occasionally so as to be worked uniformly on all four sides, instead of on only two sides as is done in a universal mill. The blooms in ordinary practice are then rolled into bars in

another mill, from which they emerge in the form of strips about 8 inches wide that are cut into pieces about 30 inches long to form the sheet bars. The ingot is thus usually rolled in a direction parallel to the length of the sheet bars, so that the subsequent rolling of the sheets takes place in a direction at right angles to the previous working; whereas in both of the experiments here described the rolling of the bars and that of the sheets were in the same direction, that is, parallel to the width of the bars.

The number of passes in the universal mill varied from 28 to 38, depending on the temperature and softness of the ingots. The vertical rolls were adjusted on only about five passes near the middle of the rolling and then left fixed, to straighten out the edges of the long plate. The horizontal drafts varied from 1 inch at the start to $\frac{1}{16}$ inch at the finish of the rolling. To give an idea of the temperatures at which this rolling was performed, a few readings on the first heat of the 1919 experiment, taken with a Leeds and Northrup optical pyrometer, are summarized below:

	Degrees F.
Ingots leaving soaking pits	2,150 to 2,400
Ingots during first part of rolling	1,965 to 2,065
Bars during latter part of rolling	1,860 to 1,965

After rolling, the long plates were cropped at top and bottom and cut in half before going to the cooling table.

SHEARING AND SELECTION OF SAMPLE BARS FOR EXPERIMENTAL PLATE

When cold the plates were sheared into bars weighing 32¼ pounds apiece, and the sound bars were separated from those showing split and scabby material. In only the 1917 experiment the scrap and sound bars from each ingot were carefully weighed; these weights are tabulated in detail in Appendix IV. A summary of these results follows, in which the copper-treated bars are included with the non-copper:

	Regular steel.	*Titanium-treated steel.*
Per cent front crop	2.6	2.8
Per cent other scrap	5.2	3.1
Per cent sound bars	92.2	94.1

In the 1917 experiment, the first sound bar following the "front crop" was taken as sample "a" for testing, and the last sound bar before

the bottom crop was taken as sample "d." Another sample, "c," was taken from the middle of the plate, and still another, sample "b," from midway between "a" and "c." The remaining sound bars from each ingot were rolled into sheets.

For each ingot in the 1919 experiment, the first seven sound sheet bars following the "front crop" were lettered from "a" to "g" respectively, and the third one, "c," was taken as a sample, the other six being held at the mill for possible future investigation. Other samples were "h," from the center of the long plate, and "i," the last good sheet bar before the bottom crop. For rolling into experimental plate, 16 bars immediately in front of sample "h," and 16 bars immediately behind it, were taken. Thus, about 20 per cent of the bars, all from the middle of the ingot, were taken for the plate of the 1919 experiment.

TESTING OF SHEET BARS

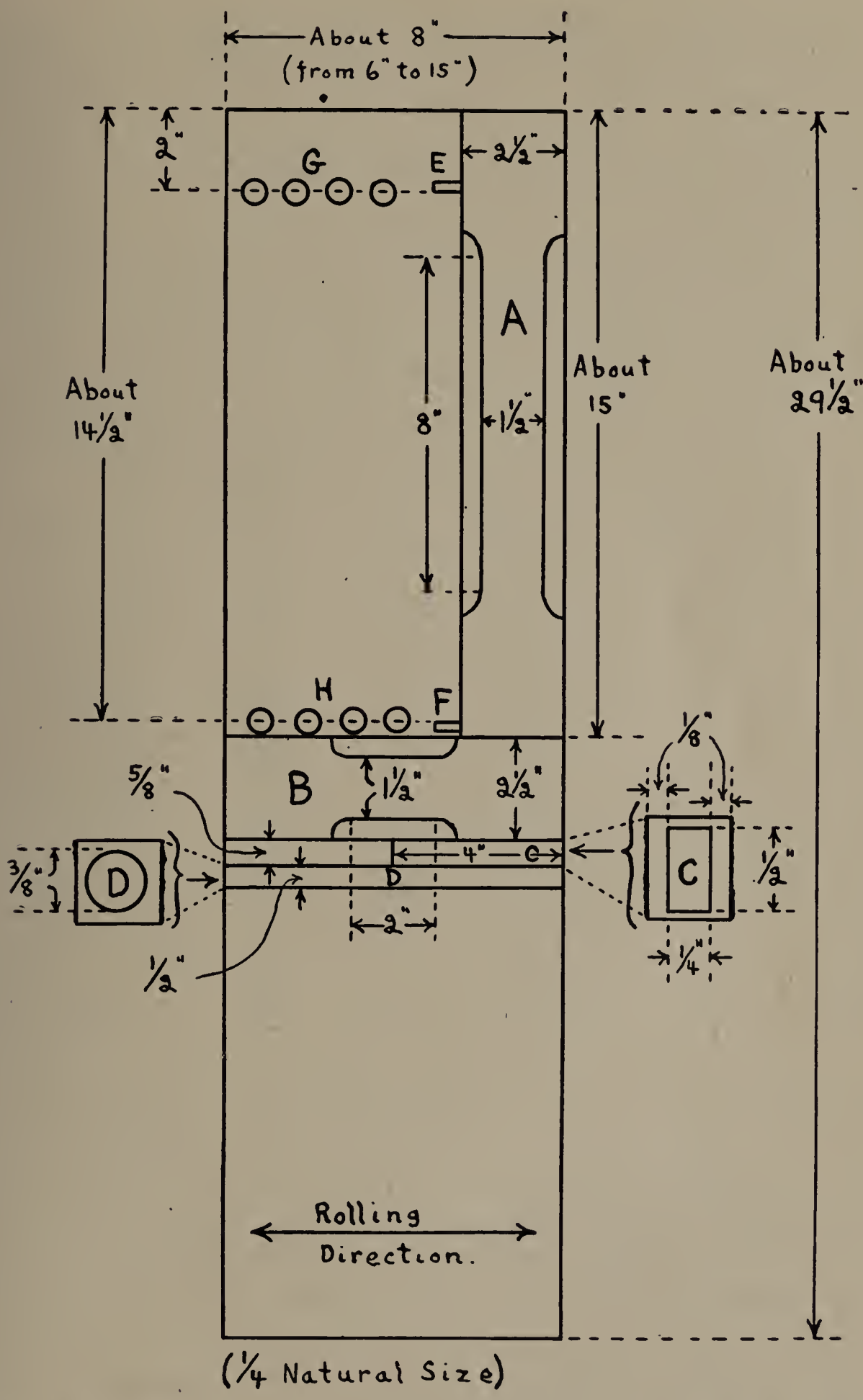
All the 1917 samples were tested, likewise all the 1919 samples except those from ingots treated with both silicon and copper. The tests, which were all made in the laboratories of the Titanium Alloy Manufacturing Company at Niagara Falls, New York, included chemical analyses; tensile tests; impact tests; alternating-impact tests; hardness tests (in 1917 experiment only); rusting tests (in 1919 experiment only); microscopic examination.

The locations of the various test specimens in each sample sheet bar of the 1917 experiment are shown in Figure 1. In the 1919 experiment the lengthwise tensile tests and the hardness tests were omitted; the impact test pieces were cut perpendicular to the rolling direction instead of parallel with it and differed in shape from those in 1917. Otherwise, Figure 1 applies to the 1919 experiment as well as to the 1917 experiment.

Chemical Tests

The samples for chemical analysis were taken with a ¾-inch drill after grinding the scale off the surfaces of the sheet bar, and every hole was drilled till the point of the tool began to appear through the under side of the bar. The methods used were practically the same as the standards of the American Society for Testing Materials. These methods are briefly as follows:

For carbon: combustion in oxygen, followed by absorption of CO_2 in a Nesbitt bulb with soda-lime.



A—Crosswise tensile test.
B—Lengthwise tensile test.
C—Impact-shear test.
D—Alternating-impact test.
E—Microsection near edge.
F—Microsection at center.
G—"Edge" drillings for analysis.
H—"Center" drillings for analysis.

FIG. 1.—Locations of test specimens in steel plate samples.

For manganese: Volumetric bismuthate method.

For phosphorus: Molybdate precipitation followed by titration.

For sulphur: Evolution into cadmium chloride solution followed by iodine titration.

For silicon: Dehydration of silica followed by volatilization with hydrofluoric acid.

TABLE 6.—AVERAGE CARBON, MANGANESE, PHOSPHORUS, SULPHUR AND COPPER CONTENT OF STEEL IN 1917 EXPERIMENT, BASED ON SHEET-BAR ANALYSES.

Steel.	Carbon.	Manganese.	Phosphorus.	Sulphur.	Copper.[a]
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R1	0.14	0.27	0.064	0.042	.....
R2	.20	.29	.125	.067	0.10
R3	.16	.34	.077	.040	.....
R4	.13	.28	.076	.034	.....
R5	.11	.23	.066	.045	.....
R6	.13	.38	.086	.049	.....
R7	.12	.35	.078	.045	.....
All R	.14	.31	.082	.046	.....
T1	.16	.30	.057	.050	.....
T2	.14	.20	.067	.044	.10
T3	.08	.28	.070	.035	.....
T4	.18	.28	.097	.041	.....
T5	.16	.32	.099	.055	.....
T6	.13	.31	.085	.044	.....
T7	.12	.29	.087	.032	.....
All T	.14	.28	.080	.043	.....
CR1	.16	.27	.070	.040	.....
CR2	.19	.29	.123	.067	.42
CR3	.18	.31	.074	.036	.....
CR1–2–3	.17	.29	.089	.048	.....
R1–2–3	.17	.30	.089	.049	.....
CT1	.12	.30	.048	.043	.....
CT2	.11	.23	.068	.050	.41
CT3	.13	.26	.069	.034	.....
CT1–2–3	.12	.26	.062	.042	.....
T1–2–3	.13	.26	.065	.043	.....

[a] Copper determined for only R2, T2, CR2, and CT2.

For copper: Double thiosulphate precipitation with final weighing of CuO.

For titanium: Colorimetric estimation, with hydrogen peroxide, of titanium insoluble in hydrochloric acid.

In some of the samples from the centers of the bars there was so much variation between drillings from the ends and middle of the drilled holes that check results, especially on phosphorus, were very

hard to get. Some of the samples were analyzed a dozen or more times in order to obtain a reliable average figure. The individual results on all the samples are tabulated in Appendix V, and some of the more important average results are given in Tables 6-8.

In explanation of Tables 6, 7 and 8, it should be noted that in the 1917 experiment, copper-bearing ingots were made in only three regular and three titanium heats; therefore the average composition of the non-copper ingots from these three heats, instead of the average of all seven heats, is given for comparison with the copper-bearing ingots. The average composition of each of the two classes of copper-bearing

TABLE 7.—AVERAGE CARBON, MANGANESE, PHOSPHORUS, SULPHUR AND TITANIUM CONTENT OF STEEL IN 1919 EXPERIMENT, BASED ON SHEET-BAR ANALYSES.

Steel.	Carbon.	Manganese.	Phosphorus.	Sulphur.	Titanium.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R21, CR21, and SR21...	0.11	0.29	0.059	0.031	0.0008
T21, CT21, and ST21...	.12	.27	.045	.031	.0007
R22, CR22, and SR22...	.14	.38	.085	.049	.0008
T22, CT22, and ST22...	.16	.31	.065	.048	.0009
R23, CR23, and SR23...	.12	.32	.065	.042	.0008
T23, CT23, and ST23...	.14	.30	.064	.045	.0008
R24, CR24, and SR24...	.17	.32	.112	.060	.0006
T24, CT24, and ST24...	.19	.31	.083	.054	.0014
R21–22–23–24.....	.13	.32	.075	.045	.0008
T21–22–23–24.....	.14	.30	.063	.045	.0008
CR21–22–23–24.....	.14	.33	.086	.047	.0007
CT21–22–23–24.....	.15	.29	.066	.046	.0008
SR21–22–23–24.....	.15	.33	.080	.045	.0008
ST21–22–23–24.....	.16	.30	.064	.043	.0012
All R, CR and SR.....	.14	.33	.080	.046	.0007
All T, CT, and ST.....	.15	.30	.064	.045	.0010

steel in this experiment is not materially different from that of the non-copper-bearing steels.

The average copper and silicon contents of the sheet-bars in the 1919 experiment are given in a separate table from the other averages because the special treatment of certain ingots with these elements made it advisable not to include such ingots with the others in computing these averages.

The average composition of ingots in the 1917 experiment, as given in Table 6, does not show any significant general differences between the regular and titanium steels, except in the copper-bearing ingots. The three regular heats in which copper-bearing ingots were made were all higher in carbon and phosphorus than the three similarly numbered

titanium-treated heats, so that the copper-bearing regular steel in this experiment is consistently higher in these elements than the copper-bearing titanium steel.

The analyses of the steel from the 1919 experiment are of greater interest, because in each case the regular and titanium-treated metal was originally part of the same heat and hence of identical composition before treatment in the ladle. The treated halves of the heats are all shown to contain more carbon than the respective regular portions. Since the ferro-carbon-titanium used contained about 7.5 per cent carbon, 75 pounds of it in a ladle holding 72,000 pounds of steel (the average amount for the treated ladles) would theoretically increase the carbon content by about 0.008 per cent. In heat 4 the theoretical

TABLE 8.—AVERAGE COPPER AND SILICON CONTENT OF STEEL IN 1919 EXPERIMENT, BASED ON SHEET-BAR ANALYSES.

Steel.	Copper.	Steel.	Silicon.
	Per cent.		*Per cent.*
CR21	0.13	SR21	0.080
CT21	.09	ST21	.095
CR22	.29	SR22	.073
CT22	.32	ST22	.087
CR23	.28	SR23	.061
CT23	.27	ST23	.079
CR24	.30	SR24	.070
CT24	.29	ST24	.102
R21–22–23–24	.06	R21–22–23–24	.008
T21–22–23–24	.06	T21–22–23–24	.008
CR21–22–23–24	.25	CR21–22–23–24	.007
CT21–22–23–24	.24	CT21–22–23–24	.010
SR21–22–23–24	.06	SR21–22–23–24	.071
ST21–22–23–24	.06	ST21–22–23–24	.091

increase would be about 0.016 per cent. The actual differences in carbon content are slightly in excess of these theoretical amounts, on account of the deoxidizing power of the titanium.

Manganese and phosphorus are both appreciably lower in all the titanium-treated portions of the heats, in spite of the fact that in every heat equal additions of ferro-manganese and ferro-phosphorus were made in each ladle, and in two cases less titanium-treated steel than regular steel was so treated, which should have given a higher content in the former steel, instead of lower. A study of this peculiar result is given in detail in Appendix VI.

In regard to sulphur, there is no marked or consistent difference shown between the regular and titanium steels.

The copper content of the C ingots of the second, third, and fourth heats does not vary materially between the titanium and regular portions, but in the first heat the titanium-treated ingot shows less copper than the regular ingot. The low average copper content in the copper ingots of this heat is due to the fact that the copper was all added in the bottoms of the molds before teeming, instead of gradually during the teeming of the steel. The individual copper determinations given in Appendix V show that the copper ingots of heats 2, 3, and 4 have from four to six times the copper content of the non-copper ingots,

TABLE 9.—SEGREGATION OF CARBON, MANGANESE, PHOSPHORUS AND SULPHUR AS SHOWN BY AVERAGE COMPOSITION OF CENTER AND EDGE SAMPLES, ALL HEATS, NON-COPPER INGOTS, REGULAR AND TITANIUM-TREATED STEEL, 1917 EXPERIMENT.

Samples.[a]	Carbon.	Manganese.	Phosphorus.	Sulphur.
Regular.				
Average of center and edge:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ra	0.14	0.32	0.092	0.049
Rb	.15	.30	.085	.049
Rc	.14	.30	.084	.048
Rd	.13	.30	.066	.038
All center	.14	.31	.089	.053
All edge	.14	.30	.074	.038
Titanium-treated.				
Average of center and edge:				
Ta	.14	.29	.091	.051
Tb	.14	.29	.087	.046
Tc	.14	.29	.083	.044
Td	.13	.27	.070	.030
All center	.14	.29	.090	.050
All edge	.13	.28	.071	.036

[a] For position of a, b, etc., see p. 42.

while in heat 1 the copper steel has only about two or three times the copper content of the non-copper steel.

The determinations of silicon on the silicon ingots show an appreciably higher content in the titanium steel than in the regular steel in every heat, and this is especially marked in the fourth heat, which received twice as much titanium as the others. Evidently the titanium-treated steel was better deoxidized than the regular steel, hence retained more of the silicon. It is interesting to note from the individual silicon figures in the appendix that the addition in each silicon ingot, though made only at the top, showed its effect throughout the ingot, even to the edge of the bottom sheet-bar sample.

The determinations of titanium show practically no difference between regular and titanium-treated steel in the first three heats, which indicates that the titanium added to them passed out of the steel into the slag while in the ladle. The silicon-titanium ingot of the fourth heat, however, shows an appreciably larger titanium content, probably because the reaction of the larger amount of titanium in this case was not completed in the ladle, which was held only the usual time. This action continued in the molds in T24 and CT24, but was stopped by the

TABLE 10.—SEGREGATION OF CARBON, MANGANESE, PHOSPHORUS AND SULPHUR AS SHOWN BY AVERAGE COMPOSITION OF CENTER AND EDGE SAMPLES, FIRST THREE HEATS, COPPER AND NON-COPPER INGOTS, REGULAR AND TITANIUM-TREATED STEEL, 1917 EXPERIMENT.

Samples.[a]	Carbon.	Manganese.	Phosphorus.	Sulphur.
Regular.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ra	0.17	0.30	0.102	0.054
Rb	.17	.30	.088	.054
Rc	.17	.30	.094	.051
Rd	.16	.30	.072	.039
CRa	.18	.28	.097	.054
CRb	.17	.29	.093	.054
CRc	.19	.29	.098	.051
CRd	.15	.29	.068	.032
Titanium-treated.				
Ta	.12	.27	.074	.053
Tb	.14	.27	.070	.047
Tc	.13	.26	.067	.043
Td	.12	.24	.049	.029
CTa	.12	.27	.068	.047
CTb	.12	.26	.068	.049
CTc	.13	.26	.064	.044
CTd	.10	.26	.046	.029

[a] For position of a, b, etc., see p. 42.

silicon in ST24, so that some titanium from the ladle addition remained in it when it solidified.

To give a general indication of the segregation that occurred in the various classes of steel, average figures are presented in Tables 9-11, but for a thorough study of this phenomenon reference should be made to the detailed tables in Appendix V.

It should perhaps be explained that, in general, segregation is expected to cause the upper part of an ingot to be higher in carbon, phosphorus, and sulphur than the lower part, and likewise the center to be higher in the same elements than the edges. This arrangement

of these impurities in an ingot results from the fact that they tend to lower the freezing point of steel. Therefore, the first steel to solidify (which is at the bottom and sides of the ingot) contains less of those elements and causes them to concentrate in the upper portion of the ingot and in the center, where solidification occurs later. Manganese, copper, silicon and titanium do not act in this way, and usually are not noticeably segregated. In the foregoing tables the differences in composition due to segregation between center and edge samples, as well as between tops and bottoms of the ingots, are brought out, and no

TABLE 11.—SEGREGATION OF CARBON, MANGANESE, PHOSPHORUS AND SULPHUR AS SHOWN BY AVERAGE COMPOSITION OF CENTER AND EDGE SAMPLES, ALL HEATS, REGULAR AND TITANIUM-TREATED STEEL, 1919 EXPERIMENT.

Samples.[a]	Carbon.	Manganese.	Phosphorus.	Sulphur.
Regular.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Rc	0.15	0.34	0.085	0.062
Rh	.13	.33	.080	.041
Ri	.10	.31	.060	.033
CRc	.17	.33	.106	.062
CRh	.13	.33	.088	.048
CRi	.11	.32	.063	.032
SRc	.15	.33	.088	.048
SRh	.15	.35	.077	.048
SRi	.14	.32	.074	.038
Titanium-treated.				
Tc	.16	.30	.074	.054
Th	.15	.31	.068	.050
Ti	.11	.30	.048	.031
CTc	.18	.29	.078	.058
CTh	.16	.30	.068	.045
CTi	.12	.28	.051	.034
STc	.16	.29	.070	.046
STh	.18	.30	.066	.044
STi	.14	.29	.056	.039

[a] For positions of c, h, etc., see p. 42.

marked difference is found in these respects between the regular, titanium and copper steels. As regards segregation of phosphorus between tops and bottoms of the ingots, the silicon-treated steels are decidedly the best.

In view of the variations in composition that have been shown within each ingot on account of segregation, any analysis of an ingot or heat of steel should not be regarded as applying significantly to any particular small portion of the ingot or heat, such as a sheet of tin plate, or a can made from it. Even the average analyses of these heats based

on the sheet-bar results do not agree in all cases with the corresponding ladle-test analyses given earlier in this report.

Physical Tests

TENSILE TESTS

The tensile tests consisted essentially in slowly pulling the two ends of a bar apart until fracture took place. The stress required to start stretching of the test bar was measured and recorded as the yield-point; the maximum stress required to cause fracture, as the tensile strength; the amount of stretching between gage marks, as the elongation; the amount of contraction in area at the point of fracture, as the reduction of area. Any defects showing in the fracture were noted as pipes or seams, and laminations; and the general appearance of the fracture surface was also recorded, whether crystalline or silky, and whether it was cup-shaped or angular. If the fracture was classified as "crystalline" no further subdivision was made, but if it was classified as "silky" it was further subdivided into "cup" or "angular." The stresses are expressed as pounds per square inch of cross section of the bar. The elongations and reductions of area are expressed as percentages of the original dimensions. A detailed description of the method and all the individual results are given in Appendix VII.

Averages and summaries of the results are given in Tables 12-15, and in computing these, the results from piped or split bars, or from bars that broke outside the gage-marks (see Appendix VII) are not included. There were so many piped bars among the samples from the 1919 experiment that the omission of results from all of them was a serious matter, but it is obviously not fair to compare a sound bar of one steel with a split bar of another. Since, however, the bars from the top, middle, and bottom of an ingot vary normally in properties, it is not fair to compare two averages, one of which includes the top bar, for instance, while the other one does not, because this bar happened to be piped. Hence, if a treated bar is piped, the only fair way to compare the steels is to omit from the averages both the piped bar and the similar bar from the untreated steel; and vice versa, to omit the treated bars corresponding to the piped untreated bars. This was done in computing the averages for the 1919 experiment, and as a result the data available were so meager as to lessen appreciably the value of these tests for comparison of the steels. The fourth heat of the 1919 experiment received twice as much titanium in its treated

portion as is called for by the best practice, so that in this experiment it was considered advisable to draw up two sets of averages, one excluding the fourth heat to illustrate steel treated with the normal amount of titanium, and one including it to illustrate all the titanium-treated steel that was made in the experiment.

In the tables for the 1917 experiment, with exceptions as noted above, each of the values for Ra, Rb, Rc and Rd is an average from seven results, as there were seven plain heats. The "All R" values give the combined average of the a, b, c and d bars of the regular steel,

TABLE 12.—AVERAGES FROM LENGTHWISE TENSILE TESTS, 1917 EXPERIMENT.

Samples.	Yield point.	Tensile strength.	Elongation in 2 inches.	Reduction of area.
Regular.	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Per cent.*	*Per cent.*
Ra	39,030	59,410	[a] 38.3	49.5
Rb	38,530	59,440	41.3	57.9
Rc	37,940	58,770	41.9	58.3
Rd	38,690	56,060	45.5	64.5
All R	38,550	58,420	[a] 41.9	57.5
All CR	41,030	60,530	[a] 41.2	54.5
R1–2–3	39,330	60,030	40.7	57.6
Titanium-treated.				
Ta	40,140	62,340	37.9	49.7
Tb	39,010	59,370	42.0	60.0
Tc	37,790	58,100	42.4	60.5
Td	33,840	52,930	46.3	64.9
All T	37,700	58,190	42.2	58.8
All CT	39,170	57,480	43.2	59.5
T1–2–3	36,340	55,350	44.0	62.0

[a] This value is high because one result on a steel of comparatively low ductility is missing from the average, the bar having broken outside the gage marks.

comprising 28 tests; the "All CR" values do the same for the copper-bearing steel, with 12 tests, as this kind of steel was made in only three heats; and the "All R1-2-3" values are likewise averages from 12 tests on the non-copper steel of the same three heats, for comparison with the averages for copper-bearing. The results from the titanium-treated steel were averaged in exactly the same way. By noting the average a, b, c and d results for either grade of steel, an idea can be obtained of the uniformity in ingots of that steel. The total averages also allow each grade of steel to be readily compared as a whole. For the 1919 experiment, only these total averages are given, and only for transverse tests.

In tabulating the average fracture characteristics, the percentage of piped bars was first computed. It is evident that many of them, especially in the 1919 experiment, were from the bottoms of ingots, so that these defects could not all be true "pipes" (that is, shrinkage cavities formed when the ingot contracted during solidification in the mold), which always occur at the tops of ingots. Those found in the bars from the bottoms of ingots, while classified as pipes for descriptive reasons

TABLE 13.—AVERAGES FROM TRANSVERSE TENSILE TESTS, 1917 EXPERIMENT.

Samples.	Yield point.	Tensile strength.	Elongation in 8 inches.	Reduction of area.
Regular.	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Per cent.*	*Per cent.*
Ra	39,490	56,740	21.9	43.0
Rb	38,530	58,230	25.0	49.1
Rc	39,040	57,600	24.8	51.1
Rd	38,290	52,500	27.8	58.3
All R	38,840	56,270	24.9	50.3
All CR	43,310	60,250	22.8	47.8
R1–2–3	40,200	58,420	24.6	49.5
Titanium-treated.				
Ta	39,910	57,110	21.2	47.4
Tb	38,960	58,540	24.1	52.0
Tc	39,430	57,630	25.1	51.3
Td	35,270	53,400	26.5	55.0
All T	38,390	56,670	24.4	51.7
All CT	39,370	55,780	25.8	52.1
T1–2–3	37,190	54,270	25.2	53.2

TABLE 14.—AVERAGES FROM TRANSVERSE TENSILE TESTS, 1919 EXPERIMENT.

Samples.	Yield point.	Tensile strength.	Elongation in 8 inches.	Reduction of area.
Regular.	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Per cent.*	*Per cent.*
R21–22–23	38,540	56,740	25.2	46.9
CR21–22–23	39,570	56,840	24.8	51.0
SR21–22–23	40,130	58,200	26.5	48.9
All R	39,890	58,600	25.1	45.4
All CR	40,710	58,040	24.1	48.8
All SR	41,040	59,160	26,9	47,7
Titanium-treated.				
T21–22–23	36,280	53,780	27.0	52.5
CT21–22–23	38,370	55,170	25.2	55.2
ST21–22–23	37,950	56,650	26.2	42.6
All T	37,390	55,670	26.3	50.0
All CT	39,220	56,610	23.6	49.1
All ST	38,100	57,540	25.9	42.2

because of similarity of appearance, actually arose from the splitting or lapping of the bottom of the ingot in rolling. In either case, whether from the top or bottom of an ingot, a pipe or split simply means that the portion discarded at the shears from that end of the rolled-out ingot was not made large enough to insure sound metal in the sheet bars.

The average percentage of piped bars having been computed for each class of steel, the fractures of the remainder were divided into two classes, "Laminated" and "Uniform," on the basis of defects, and into three classes, "Crystalline," "Silky Cup," and "Silky Angular," on the basis of appearance. The number in each group of the classification by character of fracture is the per cent of the total number of fractures for each grade of steel; while the percentage in each group of the classification by appearance is based only on the fractures that were not piped. The seamy fractures are included under "Laminated"; the slightly laminated fractures are included under "Uniform" in the 1917 experiment; and the half-cup and three-quarter-cup fractures are included under "Cup."

The chief deduction to be drawn from these tables of averages is that the difference between any two of these steels, with respect to the

TABLE 15.—CHARACTER AND APPEARANCE OF FRACTURES AS REVEALED BY LENGTHWISE AND TRANSVERSE TENSILE TESTS, 1917 AND 1919 EXPERIMENTS.

LENGTHWISE, 1917 EXPERIMENT.

Samples.	Character of fractures.			Appearance of fractures.		
	Pipes.	Laminated.	Uniform.	Crystalline.	Silky, cup.	Silky, angular.
Regular.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ra	0	71	29	42	29	29
Rb	0	43	57	0	58	42
Rc	0	14	86	0	58	42
Rd	0	0	100	0	14	86
All R	0	32	68	11	39	50
All CR	0	49	51	8	33	59
R1–2–3	0	25	75	16	42	42
Titanium-treated.						
Ta	0	71	29	0	43	57
Tb	0	29	71	0	14	86
Tc	0	14	86	0	29	71
Td	0	57	43	0	14	86
All T	0	43	57	0	25	75
All CT	0	17	83	0	25	75
T1–2–3	0	17	83	0	33	67

TABLE 15.—CHARACTER AND APPEARANCE OF FRACTURES AS REVEALED BY LENGTHWISE AND TRANSVERSE TENSILE TESTS, 1917 AND 1919 EXPERIMENTS.—*Continued.*

TRANSVERSE, 1917 EXPERIMENT.

Samples.	Character of fractures.			Appearance of fractures.		
	Pipes.	Laminated.	Uniform.	Crystalline.	Silky, cup.	Silky, angular.
Regular.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ra	29	57	14	40	20	40
Rb	0	86	14	14	29	57
Rc	0	71	29	0	14	86
Rd	29	42	29	20	20	60
All R	14	64	22	17	21	62
All CR	0	91	9	25	0	75
R1–2–3	8	67	25	27	18	55
Titanium-treated.						
Ta	29	42	29	0	0	100
Tb	0	71	29	0	0	100
Tc	0	58	42	0	29	71
Td	0	28	72	14	0	86
All T	7	50	43	4	8	88
All CT	8	67	25	9	9	82
T1–2–3	8	59	33	9	0	91

TRANSVERSE, 1919 EXPERIMENT.

Regular.						
R21–22–23	22	45	33	20	40	40
CR21–22–23	22	45	33	0	42	58
SR21–22–23	33	56	11	0	75	25
All R	25	50	25	14	57	29
All CR	17	58	25	0	50	50
All SR	42	50	8	0	80	20
Titanium-treated.						
T21–22–23	33	11	56	0	40	60
CT21–22–23	22	22	56	0	58	42
ST21–22–23	33	45	22	0	25	75
All T	25	33	42	0	29	71
All CT	16	42	42	0	60	40
All ST	25	58	17	0	20	80

properties shown by tensile tests of sheet bars, is very slight. Although the titanium-treated steel appears to average a little more ductile but less strong and stiff than the regular, a study of the individual results presented in Appendix VII shows that this difference is not consistent among all the heats, which vary more between themselves than the two classes of steel differ from each other. The effect of copper is more definite than that of titanium on these properties, and it is shown dis-

tinctly that copper increases slightly the strength and stiffness (yield-point), with a less marked decrease in ductility. On account of segregation of the hardening elements, carbon and phosphorus, the upper parts of the ingots are stronger and less ductile than their lower parts, but this effect is shown to about the same extent in all classes of steel. It is worthy of note that the silicon-treated steels of the 1919 experiment surpass the other steels slightly in these respects.

The fracture data show that the piping or splitting was about the same in the titanium and regular steels, but the former were decidedly less laminated than the regular, except in the silicon-treated ingots, where laminations were numerous. The titanium-treated steel also showed fewer instances of crystalline spots, which appeared in only one heat of such steel, and in five of the regular heats. The regular steel, however, showed in general more cup fractures, with fewer angular, than the titanium-treated.

IMPACT TESTS

The impact tests were made by different methods in the two experiments. In 1917 bars ½ by ¼ inch in section were sheared off by the edge of a heavy pendulum swinging very close to the vise holding the bar; in 1919, bars 10 millimeters square in section were notched by a hacksaw to a depth of 3 millimeters on one side, and tested in the same vise mentioned above, but with the pendulum swinging nearly an inch above it, so that the bar was broken by a very sudden bend at the notch, instead of by shearing at an unnotched section. In both cases the energy remaining unused by the fracture was obtained by measuring the swing of the pendulum after breaking the bar. The total energy developed was known, and the difference was the energy consumed in breaking the test bar, and this difference, expressed in foot-pounds, is the figure given in the tables. These methods of testing are described in detail in Appendix VIII, where the results of the individual tests are tabulated.

The average results which are given in Tables 16 and 17, along with those from the alternating-impact and hardness tests, to be described later, were obtained by averaging the individual results in the same way as was described for the tensile tests. In the 1917 experiment there was a complete series of results of impact-shear tests, but in 1919 the notched-bar averages were more or less impaired by the necessary omission of so many piped bars and the corresponding bars from the other class of steel, as was noted also in the tensile tests. For the reasons

given on page 51 two sets of averages from the 1919 experiment are given, one excluding the fourth heat, which differed from the others in its titanium treatment, and one including it.

The impact tests show no noteworthy differences between the regular and titanium-treated steels, except possibly in the 1919 experiment. Here the titanium steel appears somewhat more resistant than the regular in the averages, but when the individual results in Appendix VIII are studied, it is found that this superiority occurs in only the first two heats, and is not general. However, no specimen of steel to which the normal amount of titanium was added gave a result lower than 32, while five of the regular specimens gave lower results. The

TABLE 16.—AVERAGES OF IMPACT AND HARDNESS TESTS, 1917 EXPERIMENT.

Samples.	Impact-shear test.	Alternating-impact test.	Hardness test.
Regular.	*Foot pounds.*	*Alternations endured.*	*Brinell No.*
Ra	63.7	960	112.4
Rb	65.1	1,125	115.6
Rc	66.1	1,121	114.4
Rd	68.9	1,138	109.4
All R	66.0	1,086	113.0
All CR	67.2	926	120.3
R1–2–3	65.0	1,089	112.1
Titanium-treated.			
Ta	65.3	819	113.7
Tb	66.3	1,134	116.4
Tc	67.4	1,091	109.1
Td	68.7	1,320	103.1
All T	66.9	1,091	110.6
All CT	66.3	1,045	111.5
T1–2–3	67.7	1,091	105.4

greater uniformity of the titanium steel is thus indicated, and the results on the fourth heat also show the same thing. The poor showing of the silicon-treated ingots in this test is especially marked.

ALTERNATING-IMPACT TESTS

The alternating-impact tests involved the rapid bending of one end of a cylindrical bar backward and forward by repeated blows while the other end was rigidly clamped in a vise. Each blow produced the same amount of bending, and the blows were continued until fracture took place. The details of manipulation for this test are described in Appendix IX, and were practically the same in both experiments. The results

are expressed as the number of alternations or blows required to produce complete fracture of a bar. They are tabulated individually in Appendix IX, and averages, computed in the same way as has been described for other tests, are given in Tables 16 and 17.

Little difference was shown by these tests between the regular and titanium-treated steels without copper, but the titanium-treated copper steels were appreciably more resistant to these repeated stresses than the regular copper steels. The silicon-treated ingots showed up better in this test than the other ingots of the 1919 experiment, the silicon-titanium ingots averaging especially high.

TABLE 17.—AVERAGES OF IMPACT TESTS, 1919 EXPERIMENT.

Samples.	Notched-bar impact test.	Alternating-impact test.
Regular.	*Foot pounds.*	*Alternations endured.*
R21–22–23	42.2	782
CR21–22–23	44.6	810
SR21–22–23	35.7	1,089
All R	37.0	733
All CR	40.4	784
All SR	34.2	1,004
Titanium-treated.		
T21–22–23	45.3	790
CT21–22–23	43.7	885
ST21–22–23	36.1	1,151
All T	39.8	756
All CT	37.8	890
All ST	34.7	1,125

HARDNESS TESTS

The hardness tests were made on the ends of the impact-shear bars of the 1917 experiment, by pressing a 10-millimeter ball into the flat surface of the bar by a load of 1,000 kilograms for 30 seconds. The hardness number reported was computed from the diameter of the resulting depression, a higher number indicating a smaller depression and greater hardness. Details of this test are given in Appendix X, and averages computed in the usual way are given in Table 16. They show the titanium-treated steel to average softer than the regular, but this is due merely to accidental differences between the heats, there being more comparatively soft heats among those treated with titanium

than among the others. The hardening influence of copper, however, is quite definitely brought out by the individual result as well as by the averages.

RUSTING TESTS

Atmospheric corrosion tests were made on machined specimens cut from the sheet bars representing the middle of every ingot in the 1919 experiment. The specimens were exposed to the weather for two consecutive periods of six months each, and at the end of each period they were cleaned chemically and the loss in weight was determined. A detailed description of the test and the results are given in Appendix XI. It is shown that the titanium and silicon treatments of the steel had no effect on the rusting, but the copper additions had a very consistent effect in retarding it. In every kind of steel the copper-bearing specimen lost less weight than the corresponding specimen without copper. The loss of all the copper-bearing steel averaged 2.8 per cent in six months, while that of the steel to which no copper was added averaged 3.35 per cent in six months. After the bars were cleaned an additional exposure of six months gave a loss of 3.36 per cent for the copper-bearing steel and of 3.73 per cent for the other steel.

OBSERVATIONS ON PHYSICAL TESTS

The results of the physical tests should be studied in connection with the chemical analyses in order to appreciate how much of the difference in physical properties is due merely to difference in chemical composition. For instance, the slightly greater average softness, ductility, resistance to repeated impacts, and lack of stiffness and strength, of the titanium-treated steel are probably due, at least to a considerable extent, to the lower manganese and phosphorus in this steel as compared with the regular. This is especially true of results from the 1917 experiment, where the carbon also is lower in the titanium steel. Furthermore, in this experiment the three regular heats in which copper-bearing ingots were made happened to average high in all the hardening elements, while the three titanium-treated heats in each of which copper was used on one ingot averaged low in these elements, and the physical results reflect this chemical condition. For this reason, a study of the effect of titanium treatment on the physical properties of steel should be based only on a comparison of the seven non-copper regular ingots with the seven non-copper titanium-treated ingots. From a comparison of the copper-bearing with the non-copper ingots from the same heats, how-

ever, it is apparent that the former show a consistently higher yield-point (or stiffness), strength, and hardness, with a little less ductility. This is probably due to the copper addition directly, or perhaps also in part to the fact that the copper steel was a little harder to roll and hence was finished colder in the mill.

In the 1919 experiment the results are more comparable on account of the fact that all classes of steel were obtained from each heat. The copper-bearing ingots were superior to the non-copper in all respects except elongation and impact resistance. The silicon ingots excelled in strength and resistance to vibration, but were poor in impact resistance and reduction of area. They also showed more laminations in their fractures than the others. In this matter of uniformity of structure as shown by freedom from laminations in tensile fractures, all the titanium-treated steels were decidedly superior to the regular, and their comparative freedom from crystalline spots, which indicate local brittleness due to segregations, is also an advantage. In general, the indications are that the titanium-treated steel is more uniform than the regular in certain physical aspects.

Metallographic Tests.

The sections for microscopic examination were cut from each sheet-bar sample at points shown on Figure 1. Both sections were parallel to the direction of rolling, about 5/8 inch long, as wide as the thickness of the plate, and taken perpendicular to the surface of the sheet-bar. The "edge" section was about 2 inches from one of the rolled edges, and the "center" section about midway between the edges. They were carefully polished for the microscope in the usual way, and were all examined before etching, the general abundance, size and kind of non-metallic inclusions present being noted. A magnification of about 180 diameters was used for this examination, and two observers checked each other as to the results on every specimen. The results were recorded by a system of classification, or grading, which differed somewhat in the two experiments. In both experiments, separate classifications were made in regard to sulphide inclusions, and slag inclusions, the amount and distribution present in a given specimen being indicated by a certain definite notation. In the 1917 experiment, the terms used were: "Very small," "small," "medium," "large," and "very large." The meanings of these terms as applied either to slag or sulphides are perhaps best explained by the series of typical photomicrographs (Figures 2–11). It should be understood that the distribution, or

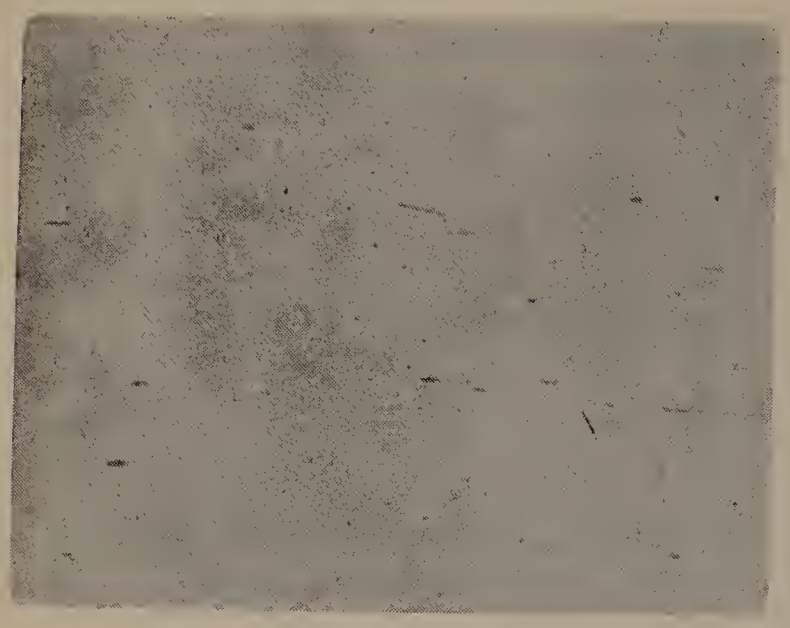


FIG. 2.—Very small.

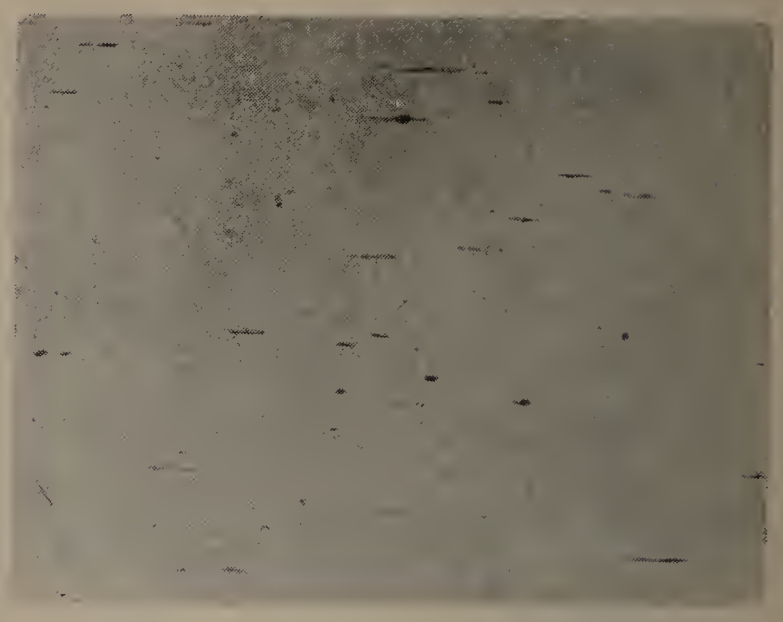


FIG. 3.—Small.

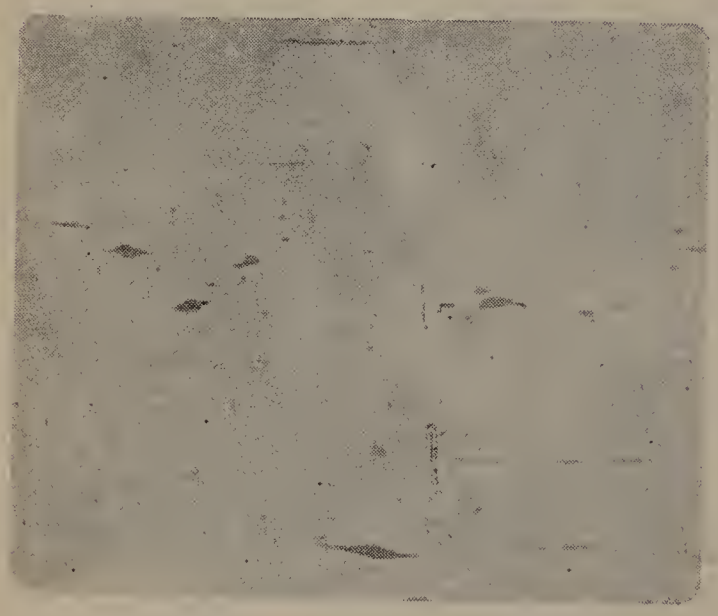


FIG. 4.—Medium.

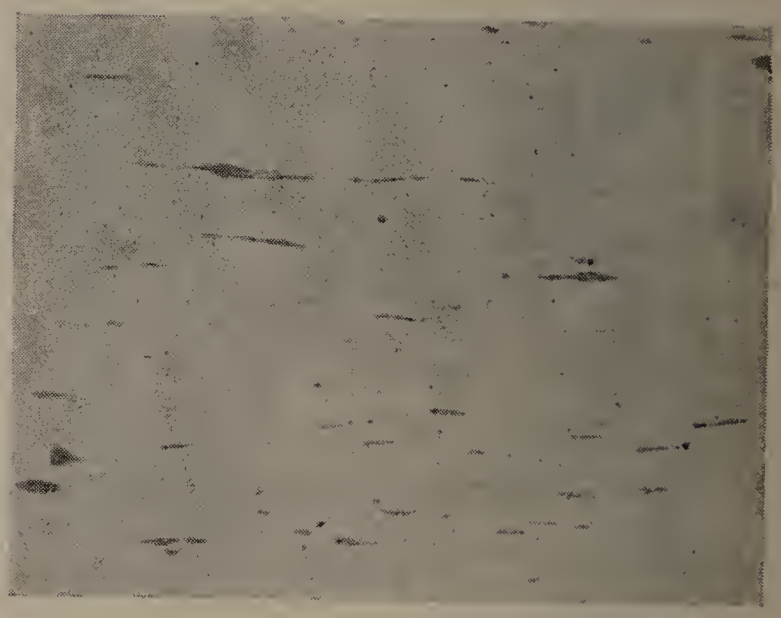


FIG. 5.—Large.

FIG. 6.—Very large.

FIGS. 2–6.—Typical views of sulphide inclusions in sheet bars illustrating various classes into which microsections were placed, according to the amount and distribution of sulphides found in them. Unetched sections from the 1917 experiment magnified 150 diameters.

FIG. 7.—Very small.

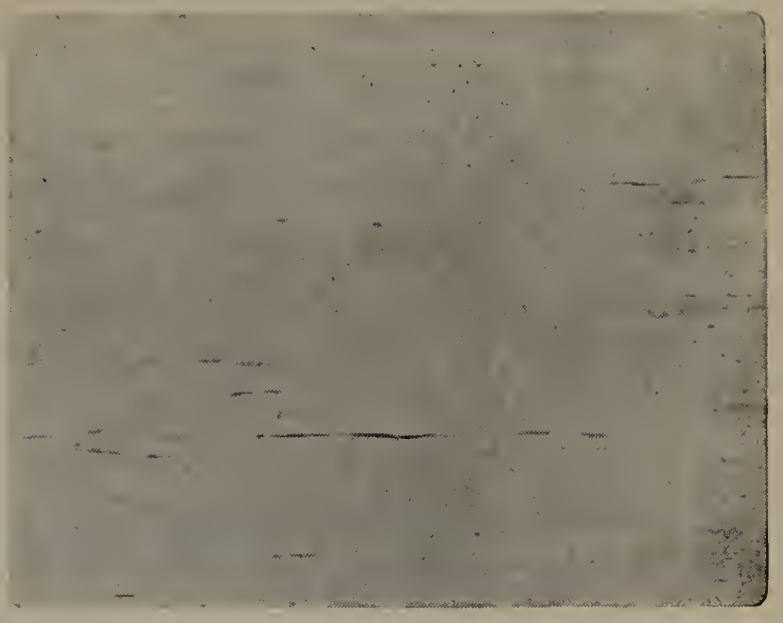


FIG. 8.—Small.

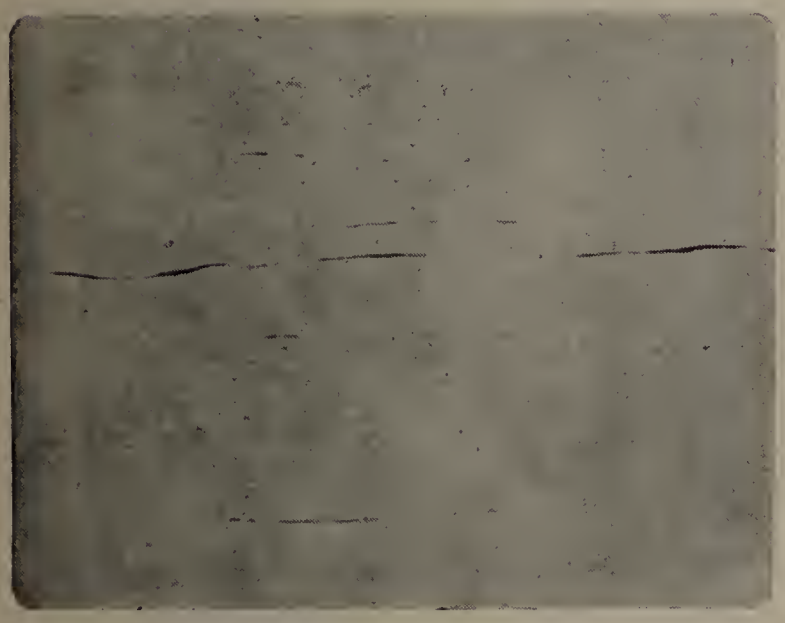


FIG. 9.—Medium.

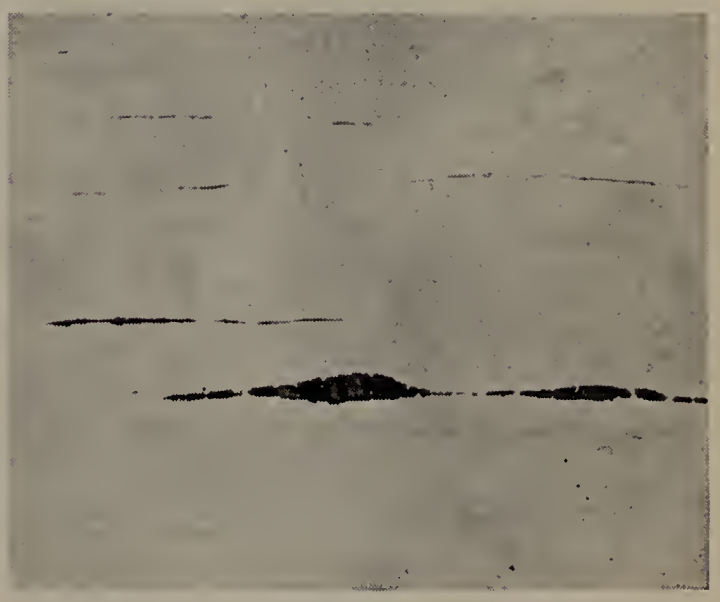


FIG. 10.—Large.

FIG. 11.—Very large.

FIGS. 7–11.—Typical views of slag inclusions in sheet bars illustrating the various classes into which the microsections were placed, according to the amount of slag found in them. Unetched sections magnified 150 diameters. Figs. 8–11 from the 1917 experiment. Fig. 7 from the 1919 experiment.

amount of segregation, of the sulphides was taken into consideration in this classification as well as the total amount of sulphur present, which is, of course, best shown by the chemical analyses. Thus, a section in which were several segregated streaks such as appear in the photomicrograph illustrating the "very large" class, was placed in this class although other portions of the section might be nearly free from sulphides. This was also true to a less degree in the slag classification.

In the 1919 experiment, the procedure was similar, except that numbers were used in the slag classification, 4 corresponding to "very small," 3 to "small," 2 to "medium," 1 to "large," and 0 to "very large." Only three classes were used for sulphides—B for "badly segregated," S for "slightly segregated," and U for "uniformly distributed."

A few of the microsections contained long single streaks; these were scale due to a fold in the rolling, slag in the remnants of the pipe in the ingot, or slag picked up from the bottom of the soaking-pit. In such cases, where the defect was certainly due to insufficient top-cropping or bottom-cropping at the plate shears, these streaks of slag or scale were not considered in the regular classification. With the exceptions, as noted above, of a few folds containing scale, or some particles resembling alumina probably picked up from the soaking pits, no inclusions were found in these samples other than the usual silicates, or slag particles, and the still more common sulphides, largely composed of manganese sulphide mixed with varying percentages of iron sulphide.

The notes on all these specimens from both experiments are given in detail in Appendix XII, and the results are summarized in Table 18. For these averages, the notes on slag in the 1917 experiment were transformed into numbers as in 1919, and these numbers were averaged, giving equal weight to the edge and center specimens, and to each bar from the various locations in the ingot. A larger number thus signifies freedom from slag inclusions, and a smaller number means dirty steel. Only three grades for sulphide distribution were retained as in the 1919 experiment, the "very small" and "small" classes of the 1917 experiment being combined under U for "uniform," the "medium" class being under S for "slightly segregated," and the "large" and "very large" classes being combined under B for "badly segregated." The averages for the 1919 experiment are not impaired in this work by the prevalence of piped sheet-bars, because all the piped bars, as well as the sound ones, were examined. The averages for each separate heat are therefore given in the table, and are of particular interest for comparisons between the regular and titanium steels which in this experi-

ment were made from the same heats. Two sets of general averages are given, as was done for the physical tests, because of the unusual treatment of the titanium portion of the fourth heat.

After the examination of the polished sections and the classification in regard to inclusions were finished, the sections were etched with a 10 per cent solution of nitric acid in alcohol. This reagent attacks the boundaries of the iron crystals or ferrite grains, showing the grain size, and also darkens the particles of pearlite or sorbite, which contain all the carbon in the steel. In specimens where the carbon was not uniformly distributed, but arranged in streaks, the darkening of the carbon-bearing constituent in these streaks made them appear darker on the surface of the specimen even without any magnification. The distribution of phosphorus also had an effect in making the streaks more or less distinct when viewed without magnification. The specimens were classified in this respect by examination without the microscope, and the results are tabulated under "macrostructure" in Appendix XII. The meanings of the terms applied to the different classes in the 1917 experiment are illustrated by a photograph taken at a magnification of three

TABLE 18.—AVERAGE SLAG GRADES AND SULPHIDE DISTRIBUTION, STEEL OF 1917 AND 1919 EXPERIMENTS.

1917 EXPERIMENT.

Samples.	Slag grade. [a]	Proportion graded for sulphides as—		
		Uniform.	Slightly segregated.	Badly segregated.
Regular.		*Per cent.*	*Per cent.*	*Per cent.*
Ra	2.72	50	29	21
Rb	2.93	29	42	29
Rc	2.28	29	42	29
Rd	2.50	86	7	7
All R	2.61	48	30	22
All CR	2.54	50	29	21
R1–2–3	2.54	37	42	21
Titanium-treated.				
Ta	3.36	57	29	14
Tb	3.21	50	43	7
Tc	2.71	64	22	14
Td	2.28	86	14	0
All T	2.90	64	27	9
All CT	3.00	58	25	17
T1–2–3	3.25	67	21	12

[a] Based on scale given on page 62.

TABLE 18.—AVERAGE SLAG GRADES AND SULPHIDE DISTRIBUTION, STEEL OF 1917 AND 1919 EXPERIMENTS.—*Continued.*

1919 EXPERIMENT.

Samples.	Slag grade. [a]	Proportion graded for sulphides as —		
		Uniform.	Slightly segregated.	Badly segregated.
Regular.		*Per cent.*	*Per cent.*	*Per cent.*
R21	2.17	67	0	33
CR21	2.08	67	17	16
SR21	1.17	100	0	0
R22	2.00	33	0	67
CR22	2.08	17	33	50
SR22	.92	83	17	0
R23	2.25	67	0	33
CR23	2.25	50	17	33
SR23	.83	100	0	0
R24	2.08	33	0	67
CR24	2.08	33	0	67
SR24	.92	50	33	17
R21–22–23	2.14	55	0	45
CR21–22–23	2.14	45	22	33
SR21–22–23	.97	94	6	0
All R	2.12	50	4	46
All CR	2.12	42	16	42
All SR	.96	83	13	4
Titanium-treated.				
T21	2.58	67	0	33
CT21	2.25	50	17	33
ST21	1.00	100	0	0
T22	2.17	50	17	33
CT22	2.42	67	0	33
ST22	1.08	100	0	0
T23	1.92	67	0	33
CT23	2.08	67	17	16
ST23	.83	100	0	0
T24	1.33	67	0	33
CT24	1.33	50	0	50
ST24	1.25	100	0	0
T21–22–23	2.22	61	6	33
CT21–22–23	2.25	61	11	28
ST21–22–23	.97	100	0	0
All T	2.00	63	4	33
All CT	2.02	59	8	33
All ST	1.04	100	0	0

[a] Based on scale given on page 62.

diameters (Figure 13). In the 1919 experiment the procedure was similar, but the specimens were divided among four classes instead of five and the grading was recorded by numbers. The averages were computed in a manner similar to that adopted for the slag classifications, the notes of the 1917 experiment being transformed into numbers. The

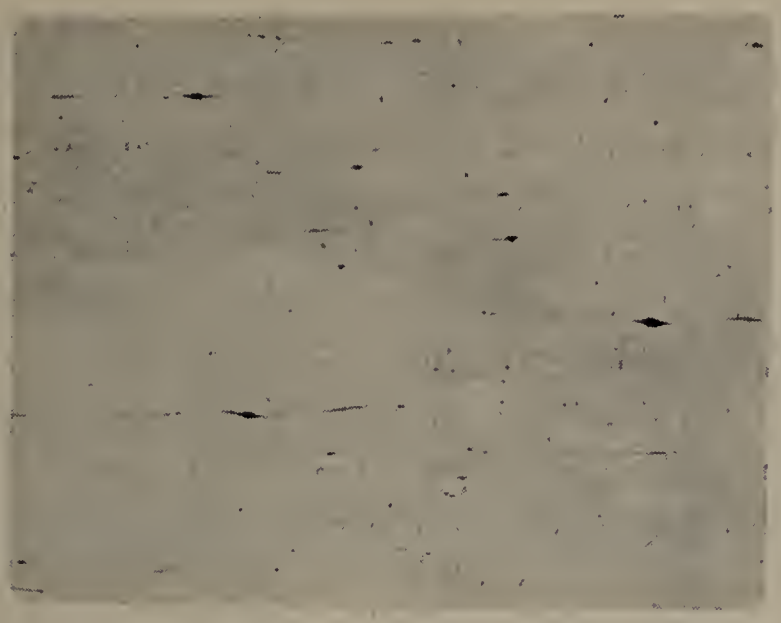


FIG. 12.—Slag inclusions typical of the sheet-bar samples from the silicon-treated ingots of the 1919 experiment, unetched and magnified 150 diameters.

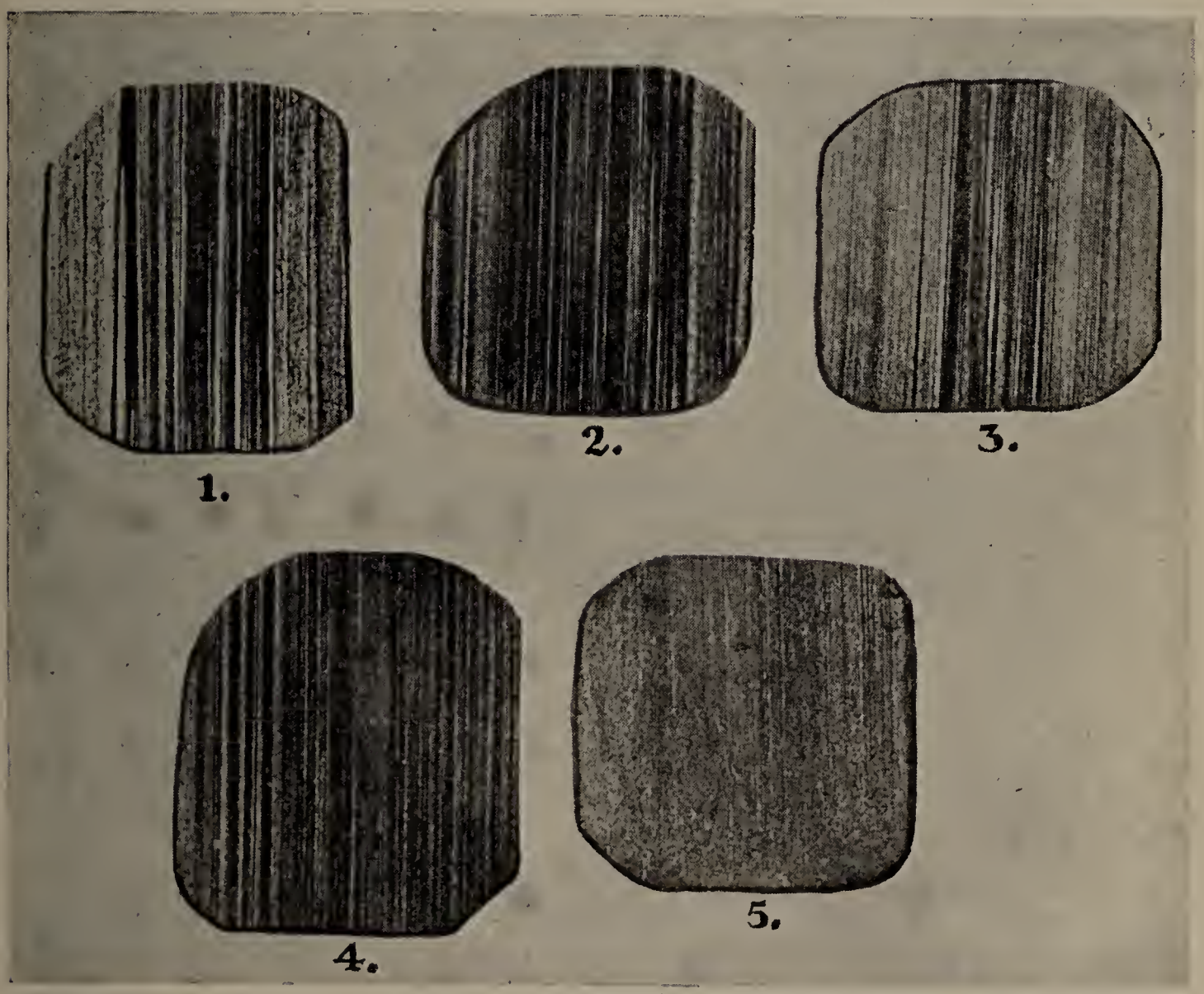


FIG. 13.—Typical microsections from sheet bars of the 1917 experiment, enlarged three diameters, illustrating the classification in regard to macrostructure after etching. No. 1 illustrates "very bad" class; No. 2, "bad"; No. 3, "poor"; No. 4, "fair"; No. 5, "good." The classification was based on the number and distinctness of the streaks brought out by etching with nitric acid, but these specimens were further etched with cupric chloride to make the streaks photograph better.

"bad" and "very bad" classes were combined as 0, the "poor" class was denoted by 1, "fair" by 2, and "good" by 3, as in the 1919 experiment.

The etched specimens were all examined with the microscope at a magnification of about 140 diameters, and classified in regard to carbon distribution and grain size. The amount of carbon in the specimens varied considerably, as shown by the relative abundance of the dark-etching constituent, but these amounts are best shown by the chemical analyses, and are not considered in this part of the report. The specimens were classified as to carbon distribution in the same way as in regard to macrostructure as shown in detail in Appendix XII. Photomicrographs are shown (Figures 14–17) to illustrate the terms and figures used, and the average results, computed as explained for the macrostructure, are given with the latter in Table 19.

The notes on grain size are also given in detail in Appendix XII, illustrated by photomicrographs, and summarized in the table of averages. In the 1917 experiment the specimens were divided into four classes on the basis of grain size "very small," "small," "medium," and "large," while in the 1919 experiment only three classes were used. For the table of averages, the "very small" class of the 1917 experiment was

TABLE 19.—AVERAGE GRADES FOR STRUCTURE, STEEL OF 1917 AND 1919 EXPERIMENTS.

1917 EXPERIMENT.

Samples.	Macro-structure.[a]	Pearlite distribution.[a]	Grain size classed as—		
			Small.	Medium.	Large.
Regular.			*Per cent.*	*Per cent.*	*Per cent.*
Ra	2.00	1.78	0	100	0
Rb	1.29	1.14	0	100	0
Rc	1.00	1.00	0	100	0
Rd	1.57	1.86	14	86	0
All R	1.46	1.45	3	97	0
All CR	.54	.96	25	75	0
R1–2–3	1.00	1.12	8	92	0
Titanium-treated.					
Ta	1.50	1.57	7	86	7
Tb	1.71	1.21	0	100	0
Tc	1.36	1.36	0	100	0
Td	1.71	1.79	14	50	36
All T	1.57	1.48	5	84	11
All CT	2.00	2.08	8	92	0
T1–2–3	1.92	1.96	12	71	17

[a] Based on scale given this page.

TABLE 19.—AVERAGE GRADES FOR STRUCTURE, STEEL OF 1917 AND 1919 EXPERIMENTS.—*Continued.*

1917 EXPERIMENT.

Samples.	Macro-structure.[a]	Pearlite distribu-tion.[a]	Grain size classed as —		
			Small.	Medium.	Large.
Regular.			*Per cent.*	*Per cent.*	*Per cent.*
R21	1.50	2.17	0	100	0
CR21	1.50	2.34	0	83	17
SR21	1.50	1.17	17	83	0
R22	.83	.83	0	83	17
CR22	.50	.67	0	100	0
SR22	1.84	.83	0	0	100
R23	2.00	1.84	0	83	17
CR23	1.50	1.84	0	50	50
SR23	2.00	1.84	0	67	33
R24	1.00	1.50	0	67	33
CR24	.33	.83	17	83	0
SR24	2.00	1.00	50	17	33
R21–22–23	1.44	1.61	0	89	11
CR21–22–23	1.17	1.62	0	78	22
SR21–22–23	1.78	1.28	6	50	44
All R	1.33	1.58	0	83	17
All CR	.96	1.42	4	79	17
All SR	1.83	1.21	16	42	42
Titanium-treated.					
T21	1.67	2.17	0	83	17
CR21	1.67	2.17	0	83	17
ST21	2.17	2.34	0	100	0
T22	.83	1.84	0	83	17
CT	1.17	2.17	0	100	0
ST22	1.84	1.00	0	100	0
T23	1.50	1.67	0	50	50
CT23	1.84	2.00	0	83	17
ST23	2.17	2.34	0	83	17
T24	1.67	1.67	33	34	33
CT24	1.17	1.17	16	67	17
ST24	2.34	2.34	17	83	0
T21–22–23	1.33	1.89	0	72	28
CT21–22–23	1.56	2.11	0	89	11
ST21–22–23	2.06	1.89	0	94	6
All T	1.83	1.83	8	63	29
All CT	1.46	1.88	4	83	13
All ST	2.12	2.00	4	92	4

[a] Based on scale given on page 66.

considered as "small," and the "small" and "medium" classes combined as "medium" to agree with the method of classification used in the 1919 experiment.

The results of the metallographic work presented in Table 19 show that the titanium-treated steels averaged a little better than the regular

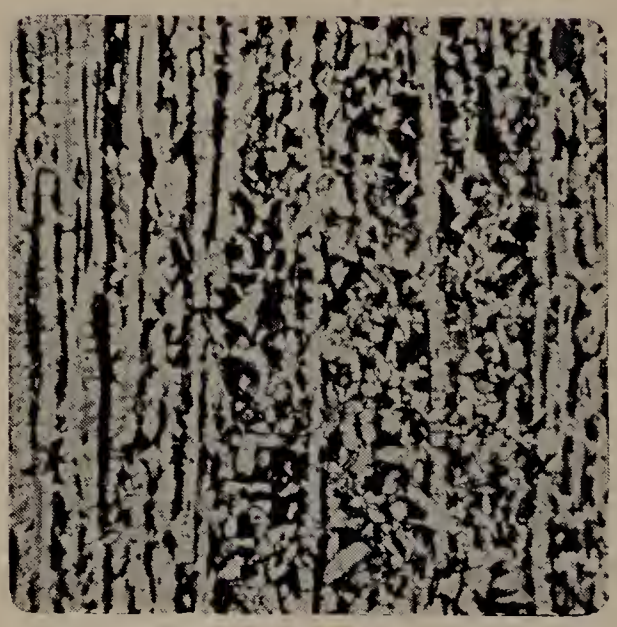


FIG. 14.—Very bad.

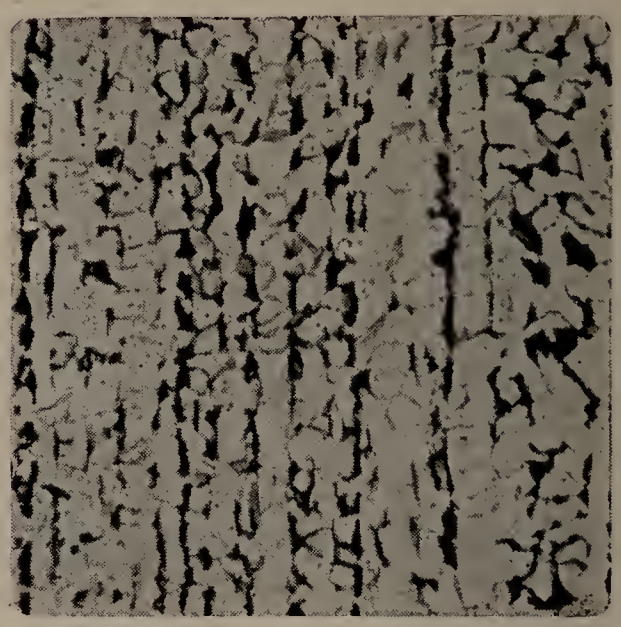


FIG. 15.—Bad.

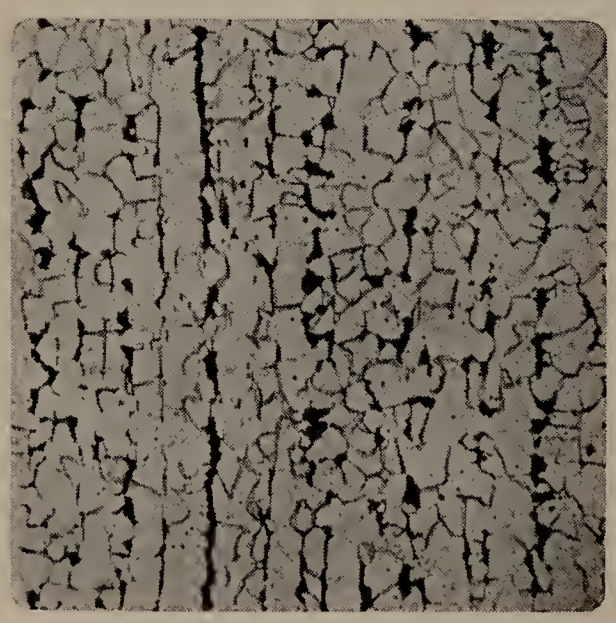


FIG. 16.—Poor.

FIG. 17.—Mediocre.

FIGS. 14–17.—Typical views of microstructure of sheet bars from the 1917 experiment, illustrating the classification in regard to carbon distribution. Etched with nitric acid and magnified 100 diameters.

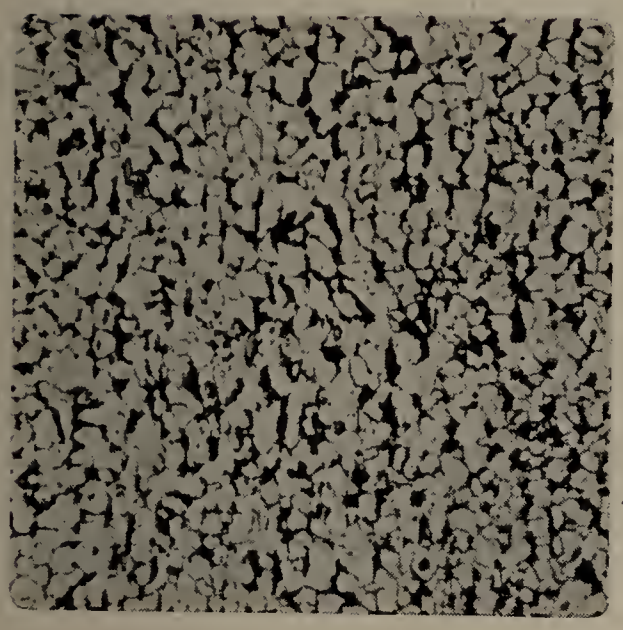


FIG. 18.—Very small.

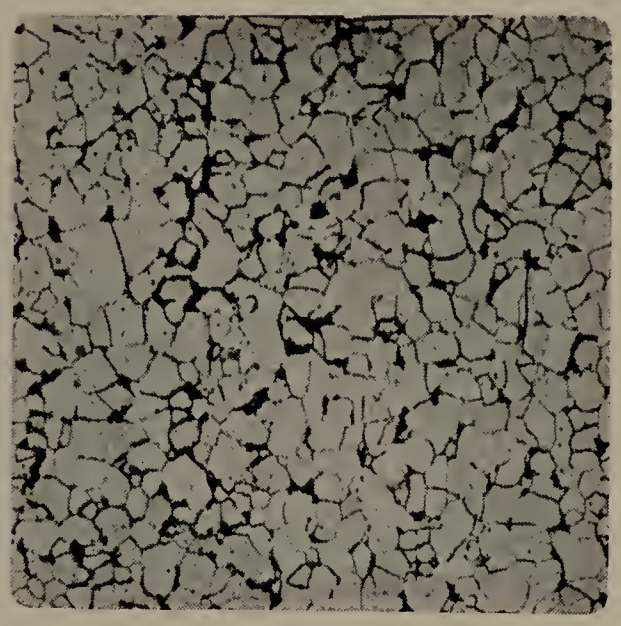


FIG. 19.—Small.

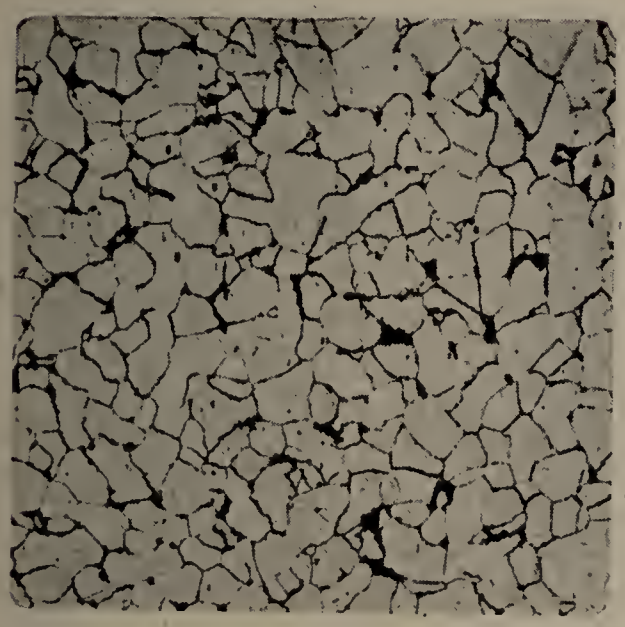


FIG. 20.—Medium.

FIG. 21.—Large.

FIGS. 18–21.—Typical views of microstructure of sheet bars from the 1917 experiment, illustrating the classification in regard to grain size, all showing uniform carbon distribution. Etched with nitric acid and magnified 100 diameters.

in regard to freedom from slag inclusions, segregation of sulphides, macrostructure, and pearlite distribution. When the individual results in Appendix XII are studied, however, such large differences are found between heats as to make it very difficult to draw general conclusions as to the comparative characteristics of these two classes of steel. Probably the most definite point brought out is that the titanium-treated steel showed consistently less segregation of sulphides and pearlite than the regular. The influence of copper is most apparent in the macrostructure of the regular steels, where it had a decidedly bad influence; but this effect of copper is not shown in the titanium-treated steels. The copper-bearing steels were somewhat finer-grained than the non-copper. Another point brought out by the 1917 averages is that the distribution of sulphide and pearlite was most uniform in the lower parts of the ingots, as is expected in all steel.

Special points shown by the 1919 experiment are the dirtiness of the silicon-treated steel, its freedom from segregation of sulphides, and good macrostructure; also the comparative dirtiness of the titanium-treated portion of the fourth heat, which received twice the usual amount of titanium for soft steel. This heat appeared abnormal in several respects, as the titanium reaction seems to have taken place partly in the molds. This would account for the slag in the ingots, and for the peculiar condition of the ST24 ingot, where the silicon prevented complete oxidation of the titanium in the steel. In ST24 the titanium prevented the oxidation of as great a portion of the silicon as was oxidized in SR24, causing a higher silicon content and less included slag. This heat seems to indicate the inadvisability of too large a titanium addition in soft steel, which agrees with conclusions drawn from former experiences of makers of this grade of steel.

The silicon-treated steel showed an excessive number of slag inclusions, even in the lower parts of the ingots, and these inclusions were finer and less elongated than most slag inclusions in soft steel. A photomicrograph is given (Figure 12) to illustrate their typical appearance. Although the silicon ingots appeared better in regard to sulphide segregation and macrostructure than the others, they were less uniform in pearlite distribution (if ST24 is disregarded) and showed more laminations in the tensile-test fractures. The titanium-treated steels were superior to the regular steels in all four respects.

The grain-size data are of interest chiefly in connection with the physical tests on the sheet bar, as a check on the uniformity of the rolling temperatures. The ferrite grain structure was later entirely

changed in rolling the sheets. The inclusions, however, always remain in the steel; the segregated streaks also can never be entirely eradicated by subsequent treatment, and must unavoidably exert a certain deleterious influence on the final tin plate. Their prevention in the original ingot and sheet bar is therefore a matter of importance. Definite results in the lessening of segregation have been shown for the titanium treatment, and although a similar prevention of coarse segregation can be secured by silicon, its use is accompanied by an increase of slag inclusions in the steel, causing a more streaky condition of the structure, while titanium treatment properly carried out does not have this latter effect. Thus, the greater uniformity of structure of the titanium-treated steel as compared with the regular, which was indicated by the physical tests, is also revealed by the metallographic work.

PRODUCTION OF TIN PLATE

HOT MILL PRACTICE

The sheet bars were heated for from 40 minutes to 1 hour and rolled in the hot mill, with their longest dimension parallel to the axis of the rolls, or, in other words, the sheets were rolled in the same direction as the ingots were rolled in the universal mill. The bars were given four or five passes in roughing, which lengthened them to about 40 inches. Two sheets of this length were then put together, one on top of the other, and rolled as a pair, being lengthened in two passes to about 76 inches. These pairs were separated momentarily and folded over once, making a pack of four thicknesses, which was sheared to straighten the ends, and reheated. The "fours" were given two passes, resulting in a length of about 72 inches; they were then separated, folded, and sheared again, giving a pack of eight thicknesses. The "eights" were reheated and finished in from three to five passes, being allowed to cool before the last pass just enough for this pass to bring them to a final length of a trifle over 76½ inches.

This practice was followed in both experiments, and in all the sheet mills on which the rolling was done. In the 1917 experiment, where all the sheet bars from each ingot were rolled as separate lots, the time between the start of roughing and the finishing of the "eights" varied from 2¾ to 3¾ hours for each ingot, the number of pairs rolled per ingot varying from 72 to 95. In the 1919 experiment only 16 pairs of bars from each ingot were rolled for the special plate.

Each pack of eight sheets was sheared into four smaller packs 19⅛ inches long in the direction of rolling, and 29$^{3}/_{16}$ inches wide. These packs were marked, to identify the respective ingots from which they came, by punching notches along an edge and clipping a corner according to a pattern which was different for each ingot. Such a mark could not be obliterated by any subsequent operation in the manufacture of the tinned sheet, and thus positively identified each one until it was cut up at the can factory.

After the sheared packs were marked they were opened, or separated into individual sheets. These sheets were about 0.012 inches in thickness. The sheets from the 1919 experiment stuck together somewhat more than is usual in ordinary commercial practice. The time required to separate the sheets, and the loss due to defective sheets after opening, are sometimes considered to give an indication of the quality of steel for making tin plate, and these data are given in detail for each lot of

steel in Appendix XIII. A summary of the results is given in Table 20, the copper-bearing steel being included with the non-copper in the 1917 experiment. The average times required in the 1919 experiment were computed from incomplete data, hence may not be very accurate.

TABLE 20.—AVERAGE SPOILAGE IN OPENING AND TIME REQUIRED PER 1,000 POUNDS IN OPENING ROLLED PACKS AT SHEET MILL.

Sheets.	Spoiled in opening.	Time required per 1,000 pounds.
1917 experiment.	*Per cent.*	*Hours.*
All R	2.0	1.34
All T	1.2	1.06
1919 experiment.		
R	6.3	3.60
CR	4.2	3.80
SR	4.5	1.40
SCR	4.9	1.70
T	7.3	3.60
CT	6.6	2.90
ST	5.9	1.10
SCT	4.3	1.40

BLACK PICKLING

After the rolled packs were opened, the sheets were pickled, or immersed in hot dilute sulphuric acid, to remove the oxide scale from their surfaces. For this operation they were placed loosely on end in wooden frames or cages, which were then lifted up and down in the acid by a crane for a given time. Afterward the cage was lifted up and down for the same length of time in a tank of water to rinse off the acid, and when this was accomplished the sheets were removed from the cage and inspected. Those with surfaces free from scale were piled up on the bottoms of the annealing boxes, while those incompletely pickled were replaced in a cage and pickled again. The special sheets in the 1917 experiment were pickled more slowly, in more dilute acid, and at a lower temperature than is customary for this work. In the 1919 experiment, however, the usual practice was followed, except that extra rinsing was performed with a hose to supplement the regular rinsing in the water tank.

In the 1917 experiment the strength of the acid for pickling every lot of steel was determined by titration. For the non-copper steel this strength varied from 6.7 to 8.0 per cent, and for the copper-bearing

steel from 7.5 to 9.2 per cent, as the copper-bearing steel was harder to clean. The temperatures varied from 65°C. to 88°C., and the time of immersion from 6 to 15 minutes, though most lots were pickled for 10 minutes or more. In the 1919 experiment the time varied from 3 to 7½ minutes. In the 1917 experiment the average loss of weight in pickling for the different kinds of steel was found to vary from 0.9 to 1.5 per cent.

BLACK ANNEALING

The sheets were annealed in coal-fired furnaces, the fire being behind a baffle-wall at the back of the furnace, and the flues to the stack being arranged along the sides near the floor. Two doors forming the whole front of the furnace permitted the entrance of the boxes containing the sheets to be annealed. When the sheets were piled on the bottoms of the annealing boxes, sheet bars were placed in the piles at certain locations, to allow the insertion between them of pyrometer couples, which consisted of constantan and iron wires. The wires were passed through the sand seal under the covers of the annealing boxes, and under the furnace doors, to Leeds and Northrup potentiometers, which indicated the temperature of each couple. In the 1917 experiment the furnace temperatures were also measured by Hoskins pyrometers, whose hot junctions were about two feet inside the furnace doors. In the 1919 experiment the furnace temperatures, as measured by couples extending through the roofs of the furnace, were kept at about 1,600°F. until cooling commenced. All other temperatures for both experiments are given in tables in Appendix XIII. The arrangement of the different lots of sheets in the furnaces is explained on page 213. In the 1917 experiment the lots were paired for annealing according

TABLE 21.—MAXIMUM TEMPERATURES REACHED AT TOPS OF LOTS OF SHEETS IN BLACK ANNEALING.

Sheets.	Temperature.	Sheets.	Temperature.	Sheets.	Temperature.
1917 experiment.	*Deg. F.*	*1919 experiment.*	*Deg. F.*	*1919 experiment.*	*Deg. F.*
R2	1,740	R21	1,250	T21	1,252
R3	1,705	SR21	1,305	ST21	1,305
CT3	1,435	R22	1,225	T22	1,215
R4	1,427	SR22	1,272	ST22	1,280
R7	1,800	CR23	1,290	CT23	1,235
R6	1,485	SCR23	1,212	SCT23	1,207
		CR24	1,235	CT24	1,238
		SCR24	1,190	SCT24	1,173

to their analyses, an R lot and a T lot of similar analysis being piled together on an annealing bottom in every case. In the 1919 experiment, the lots being much smaller, all eight lots from each heat were arranged together in the same box.

The annealing temperatures were kept decidedly lower in the 1919 experiment than they were in the 1917. Some typical curves are given in Figures 22 and 23, showing the temperature changes during the annealing of some of the lots. The maximum temperatures recorded by thermocouples at the upper and hotter parts of lots where such measurements were obtained are given in Table 21.

The rates of heating and cooling of these large piles of sheets in the annealing furnaces were slow, as may be seen by referring to the tables in Appendix XIII. Heating to the maximum temperature required from 15 to 18 hours; cooling to a suitable temperature for removal from the furnace required an additional 24 hours. This long heat treatment had an important effect on the carbon content of the sheets, and on their microstructures. Some data obtained on the reduction in carbon in the 1917 experiment are given in detail in Appendix XIII. The carbon at the centers of the sheets averaged 6.5 per cent lower than the figure shown by the ladle test when the ingots were poured, while at the edges of the sheets it averaged 59 per cent lower. Of course part of this reduction, especially at the edges, occurred during the heating and rolling of the ingots and sheet bars.

The change in microstructure during the black annealing consisted always in a broadening and shortening of the narrow elongated ferrite grains produced by the last passes in the sheet mills, and, if the temperature was high enough, in a coalescence of the fine carbide particles into coarser masses at the grain boundaries. This latter effect occurred in the 1917 experiment to a marked degree, on account of the high temperature of annealing, but only in a few lots of the 1919 experiment. Photomicrographs (Figures 24-27) illustrate the typical structures of the same sheet before and after annealing. A specimen of the same sample after hotter annealing in the laboratory is also illustrated (Figure 28) to show the different form of the carbide thus produced. For comparison a photomicrograph (Figure 29) of a sheet of lot CR3 annealed at about the same temperature as CT3 from the 1917 experiment is included, to illustrate how annealing at a higher temperature affected the structure. Further notes regarding microstructures will be found in the discussion of the testing of tin-plate by metallographic examination (p. 98).

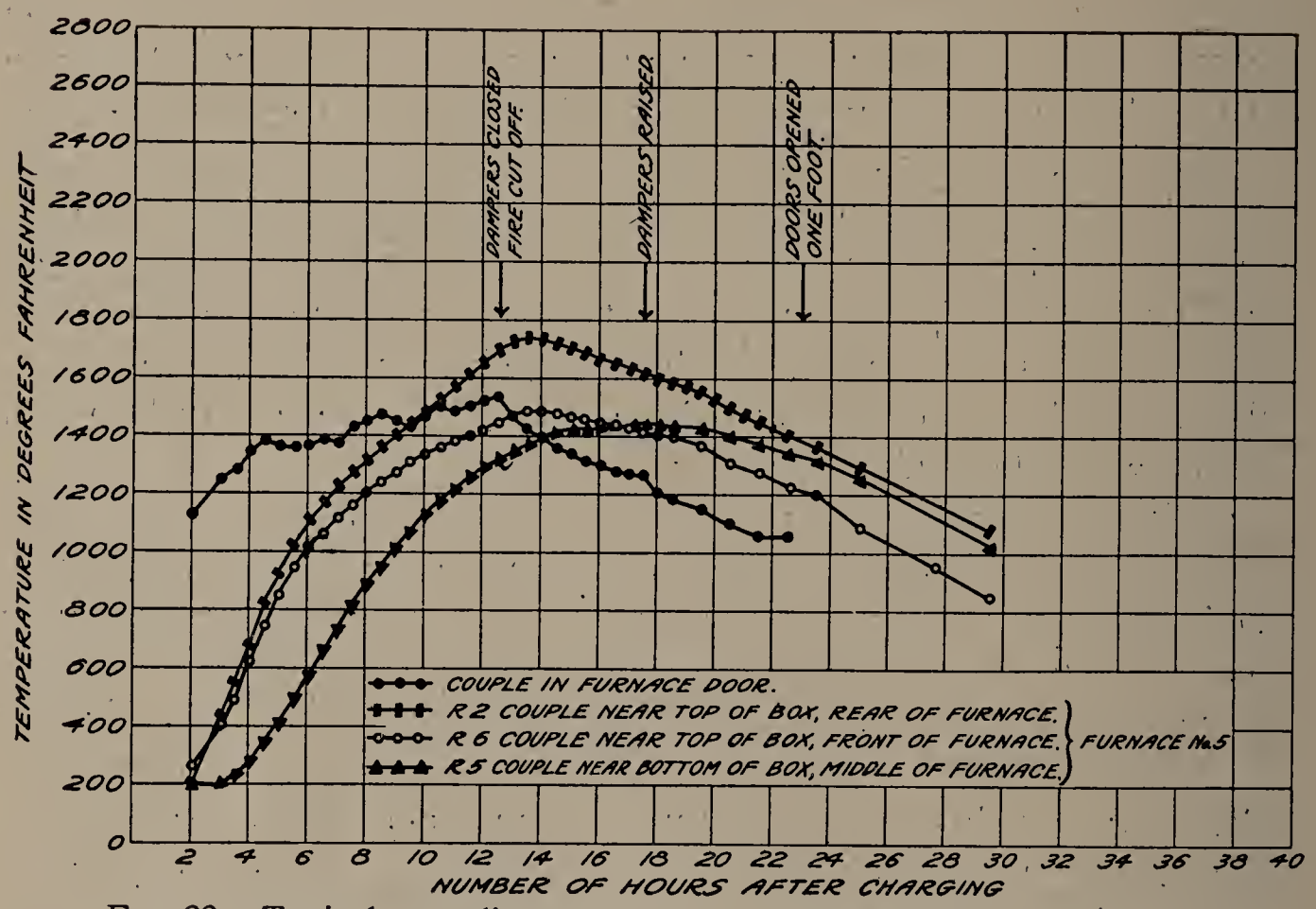


FIG. 22.—Typical annealing curves, 1917 experiment, black annealing.

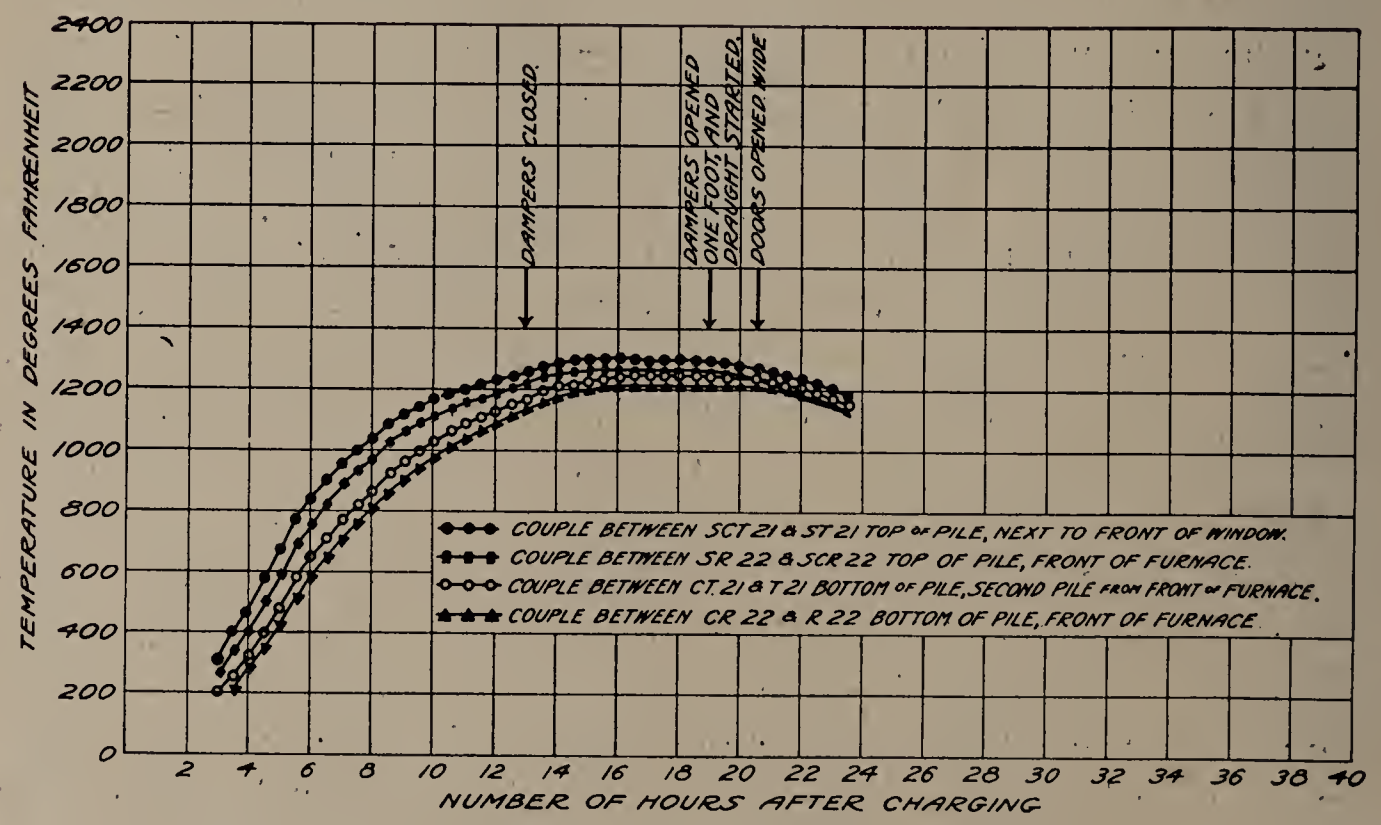

TEMPERATURE IN DEGREES FAHRENHEIT
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
NUMBER OF HOURS AFTER CHARGING
DAMPERS CLOSED.
DAMPERS OPENED ONE FOOT, AND DRAUGHT STARTED.
DOORS OPENED WIDE
COUPLE BETWEEN SCT 21 & ST 21 TOP OF PILE, NEXT TO FRONT OF WINDOW.
COUPLE BETWEEN SR 22 & SCR 22 TOP OF PILE, FRONT OF FURNACE.
COUPLE BETWEEN CT 21 & T 21 BOTTOM OF PILE, SECOND PILE FROM FRONT OF FURNACE.
COUPLE BETWEEN CR 22 & R 22 BOTTOM OF PILE, FRONT OF FURNACE.

FIG. 23.—Typical annealing curves, 1919 experiment, black annealing.

FIG. 24.—Section of hot-rolled sheet from ingot R21, 1919 experiment, parallel to direction of rolling, etched with nitric acid and magnified 200 diameters, showing great distortion of grains.

FIG. 25.—Same as Figure 24 except perpendicular to the direction of rolling, showing less distortion.

FIG. 26.—Section of same sheet as Figure 24, after black annealing, cut parallel to the direction of hot rolling, etched with nitric acid and magnified 200 diameters, showing ferrite grains not distorted, but carbides fine and arranged in lines.

FIG. 27.—Same as Figure 26 except perpendicular to direction of hot rolling.

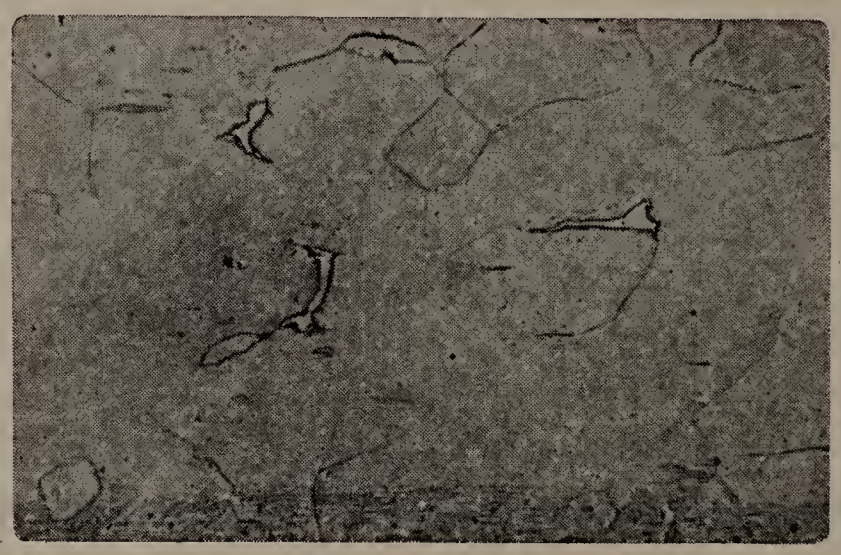


FIG. 28.—Piece of same sheet as Figure 26 annealed in laboratory at a higher temperature, etched with nitric acid and magnified 200 diameters, showing the carbides segregated or massive between the ferrite grains.

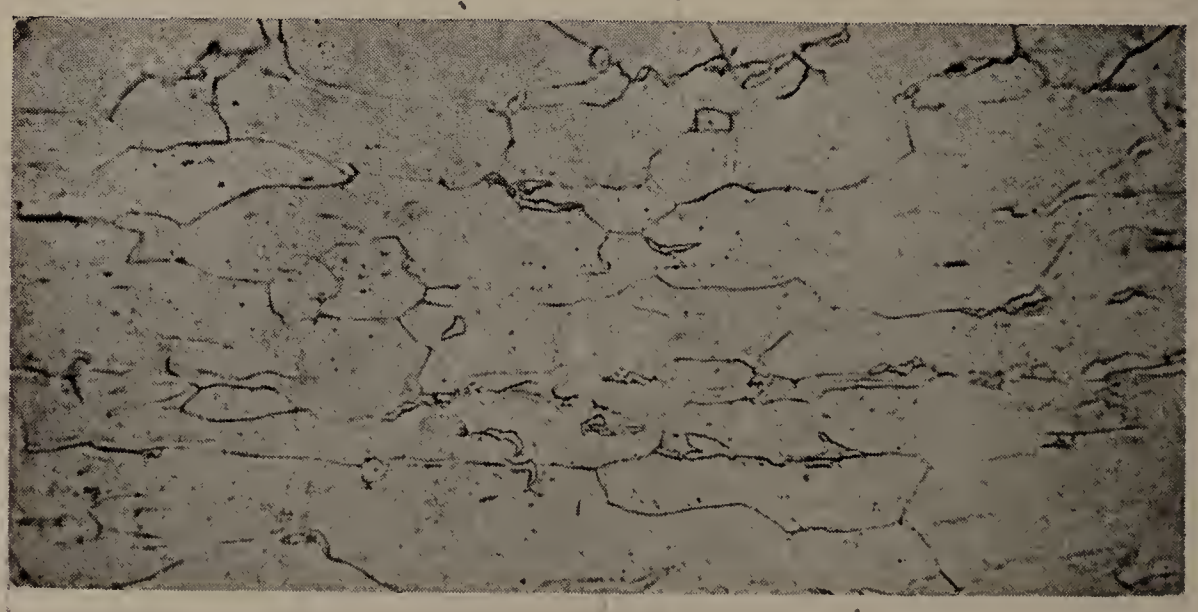


FIG. 29.—Section of finished sheet from ingot CR3, 1917 experiment, etched with nitric acid and magnified 200 diameters, illustrating the coarse structure, with massive cementite and phosphorus markings, produced by the hotter annealing given to these sheets as compared with the practice in the 1919 experiment.

After being annealed, the individual sheets in the piles were separated from each other when cold enough to handle. Several lots of the 1917 experiment stuck together very badly on account of the high annealing temperature, this being especially noticed with lots T1, R3, T3, T4, R5, R6, R7, and T7. The amount spoiled in opening, and the time consumed in this operation for each lot of the 1917 experiment, were roughly proportional to the temperature of annealing. These figures are given in Appendix XIII. Because of the low temperature of annealing in the 1919 experiment no difficulty was experienced in opening the sheets.

COLD ROLLING

After the piles were opened, the sheets were run through the cold rolls in such order that on leaving the rolls they were piled on the annealing bottoms again in the same arrangement as used for the black annealing. Three passes through the cold rolls were given in both experiments, the sheets going through the rolls lengthwise, or at right angles to previous rolling directions. These passes merely smoothed the surfaces, introducing internal strains but not changing the microstructure. After cold rolling the dimensions were approximately $19\frac{3}{16}$ by $29\frac{5}{16}$ by 0.011 inches, the thickness being measured about 1 inch from the edge. Nearly all the reduction in thickness, from about 0.012 inch before rolling, was produced in the first pass. In the 1917 experiment especial care was taken to produce a superior cold-rolled surface on the sheets, while in 1919 ordinary practice was followed.

WHITE ANNEALING

In the white annealing temperatures were taken in the same way as in the black annealing and are given in Appendix XIII. Typical curves are also given (Figures 30 and 31) to show how these temperatures varied. The arrangement of the annealing boxes in the furnaces in the 1919 experiment was the same for both annealings, but in the 1917 experiment none of the special sheets were placed at the rear, or hotter, ends of the furnaces for the white annealing. A diagram (Fig. 125) in Appendix XIII shows this arrangement. The temperatures used for white annealing were lower than in the black annealing, and the furnace temperatures were kept around 1,400° to 1,550°F. Maximum temperatures recorded by thermocouples at the upper parts of lots where such measurements were taken are given in Table 22.

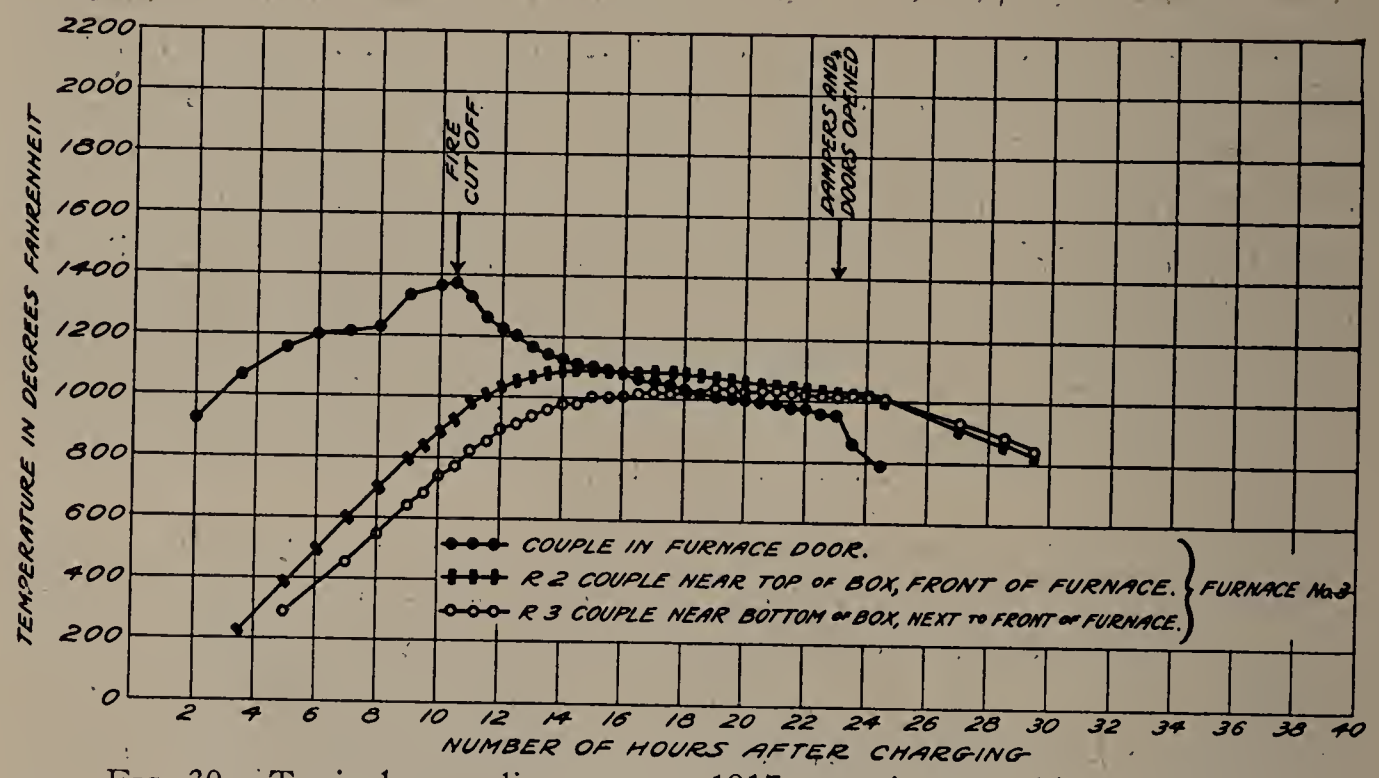


FIG. 30.—Typical annealing curves, 1917 experiment, white annealing.

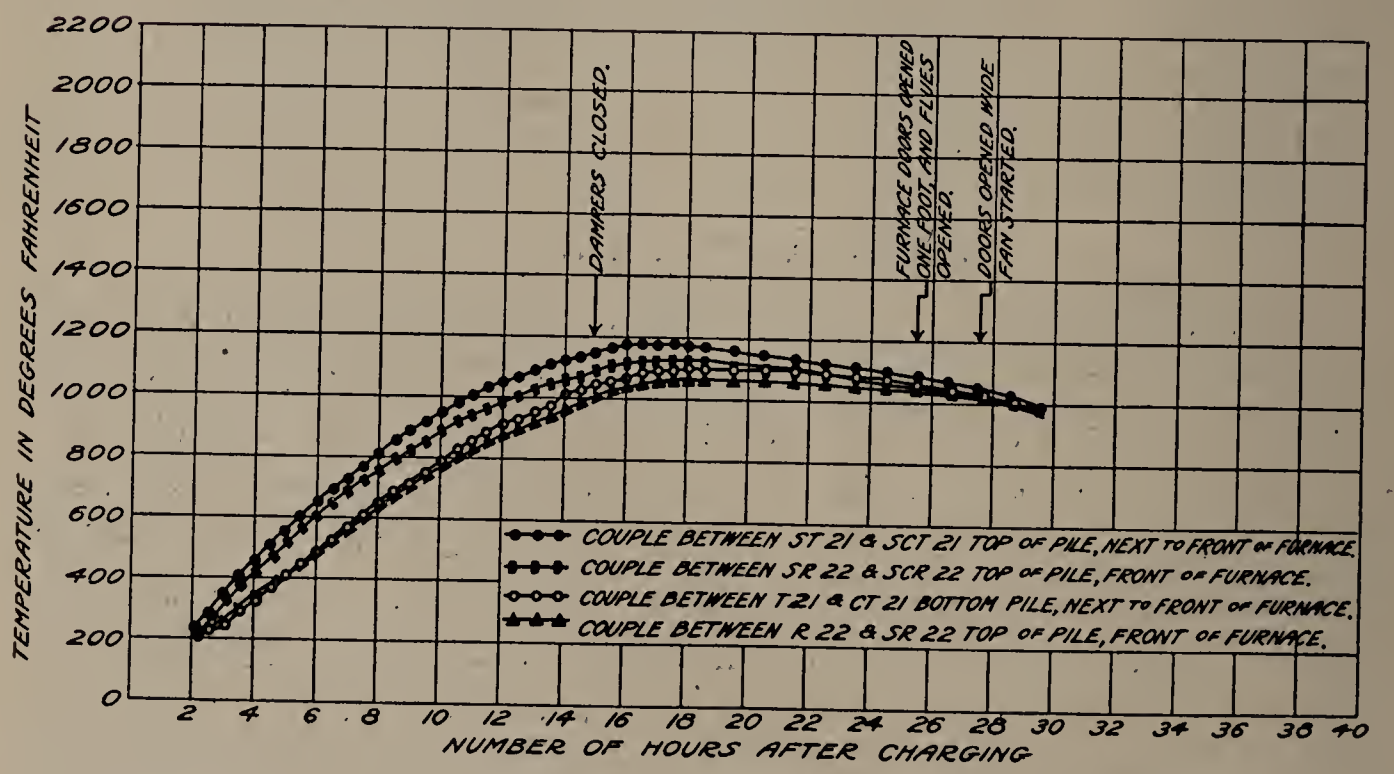

TEMPERATURE IN DEGREES FAHRENHEIT
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
DAMPERS CLOSED.
FURNACE DOORS OPENED ONE FOOT, AND FLUES OPENED.
DOORS OPENED WIDE FAN STARTED.
COUPLE BETWEEN ST 21 & SCT 21 TOP OF PILE, NEXT TO FRONT OF FURNACE.
COUPLE BETWEEN SR 22 & SCR 22 TOP OF PILE, FRONT OF FURNACE.
COUPLE BETWEEN T 21 & CT 21 BOTTOM PILE, NEXT TO FRONT OF FURNACE.
COUPLE BETWEEN R 22 & SR 22 TOP OF PILE, FRONT OF FURNACE.
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
NUMBER OF HOURS AFTER CHARGING

FIG. 31.—Typical annealing curves, 1919 experiment, white annealing.

The duration of this annealing was as long as or longer than that of the black annealing, but as the ferrite grains had not been appreciably distorted since the first annealing, and the temperatures were not high enough to affect the carbide, no noticeable change was produced in the microstructure. The function of this operation was merely to remove the strains produced by the cold rolling.

The piles of sheets were opened again when cold enough to handle, and no trouble was encountered because the temperatures had not been high enough to make them stick together. In the 1917 experiment all the sheets from each ingot had come through as a unit up to this point, but these large lots were divided up before the next operation. From each ingot two lots of about 300 sheets were taken for making the experimental cans. The lots were taken from the piles of sheets next

TABLE 22.—MAXIMUM TEMPERATURES REACHED AT TOPS OF LOTS OF SHEETS IN WHITE ANNEALING.

Sheets.	Temperature.	Sheets.	Temperature.	Sheets.	Temperature.
1917 experiment.	*Deg. F.*	*1919 experiment.*	*Deg. F.*	*1919 experiment.*	*Deg. F.*
R2	1,095	R21	1,106	T21	1,102
CT3	1,170	SR21	1,165	ST21	1,177
R4	1,070	R22	1,075	T22	1,065
R6	1,130	SR22	1,127	ST22	1,137
R7	1,100	CR23	1,150	CT23	1,143
		SCR23	1,065	SCT23	1,070
		CT24	1,115	CT24	1,123
		SCR24	1,057	SCT24	1,047

to the bars which made the spaces for the thermocouples, and toward the center of the pile from those bars. One lot from each ingot was later given a "coke-coating" of tin, and the other a "charcoal" or heavier coating. By this method of choosing sheets for can making, accurate data were assured regarding the temperatures of their annealing, but nothing was known as to the respective parts of the ingot from which they came.

In order to have material for comparison of different types of tinning pots, one pair of ingots, R3 and T4, were divided into quarters after the two 300-sheet lots had been taken. The remaining sheets of the other 18 ingots, after removal of the experimental lots, were put through the subsequent operations ahead of the special lots, and were included in the testing by inspection, or "assorting" of the tinned sheets. Since the selection of the parts of the ingots for the 1919 experiment

was made from the sheet bars, the lots of plate were not further divided at this point.

WHITE PICKLING

The white pickling was carried out in very much the same way as the black pickling, except that the sulphuric acid was a little weaker and not so hot and the sheets after pickling were kept in water with a trace of hydrochloric acid to prevent rusting before tinning. The strength and temperature of acid were measured on most of the lots in the 1917 experiment.

In the 1917 experiment considerable trouble, probably due to insufficient black pickling, was encountered from smoky edges on the sheet, which failed to brighten up in pickling at those points until long after the rest of the sheet was sufficiently pickled. The small lots used for experimental cans were pickled from 12 to 17 minutes at temperatures above 64°C. and in acid of over 6 per cent strength. The acid strengths for the large lots varied from 4¼ to 7½ per cent, the temperatures of the solution from 50° to 75°C., and the periods of immersion from 5 to 27 minutes. In the 1919 experiment the acid was stronger than in the 1917 experiment and the period of immersion varied from about 5 to 7½ minutes.

TINNING

Straits tin with an addition of 10 to 15 per cent of Banca tin was used in the pots in the 1917 experiment. Analyses of samples taken from the pots are given in Table 23.

TABLE 23.—IRON, COPPER, LEAD, ARSENIC, AND ANTIMONY CONTENT OF TIN USED IN 1917 EXPERIMENT.

Pot.	Sample number.	Iron.	Copper.	Lead.	Arsenic.	Antimony.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Edwards	T9	0.043	0.015	None.	0.009	None.
AnDo	F9	.005	.016	do.	.012	do.
Do	T12	.011	.016	do.	.011	do.
Do	F12	.003	.017	do.	.020	do.
derson	14	.013	.017	0.03	.011	do.
Do	16	.024	.014	None.	.008	do.
Combination	23	.012	.018	do.	.013	do.

The sheets were taken one by one out of the acidulated water in which they had been placed after pickling, and were fed into the tinning

machines by hand. They passed slowly down through a flux of molten zinc chloride into the liquid tin and out through a layer of palm oil. After cooling slightly on a runway, they passed through a cleaning machine consisting of a series of rolls turning at different speeds, which scrubbed their surfaces with bran or ground peanut shells, which removed most of the oil flux and left them bright and polished. They were discharged from the cleaning machines on to trucks and taken to the assorting room for inspection.

Bran was used for cleaning in the 1917 experiment, and peanut shells in 1919; the peanut shells contained sand or dirt, which scratched the tin coating deeper than the bran did.

In the 1917 experiment the coating was done in three kinds of pots. The eighteen large lots of sheets were coated in "Edwards" pots, having two baths of tin in series, and were given a commercial "coke" coating, or light coating. One of the 300-sheet lots from each ingot was also coated in the same way. The other 300-sheet lot from each ingot was coated in the same pot, but adjusted so as to give a "charcoal," or heavier, coating. Each of the quarter-ingot lots of both R3 and T4 was given one of the following coatings:

1. Coke coating on the Edwards pot, as above.
2. Coke coating on an Anderson, or single pot.
3. Charcoal coating on an Anderson pot.
4. "3A charcoal" or extra-heavy coating on a combination, or triple pot, with double cleaning.

Notes on the speeds of operation and times of immersion for these different methods are tabulated in Appendix XIII. Temperature readings with a Thwing thermometer on tin in the Edwards and Anderson pots showed 550°F. to 610°F. The second and third baths of the combination pot were considerably cooler.

In the following parts of this report, additional notation will be necessary to identify the kinds of coating on the various lots of plate in the 1917 experiment. For this purpose the letter X designates the ordinary coke coating, and is used after the number referring to the heat of steel. Similarly, the letter A used after that number denotes a heavier or charcoal coating of tin. To identify the different quarter ingots of R3 and T4, an "E" before the ingot letter means the lots from the Edwards pot, an "A" before the ingot letter means sheets from the Anderson pot, while "S" in the same location identifies the lots from the combination pot. Thus, for example, ER3X designates the quarter-ingot of R3 from the Edwards pot with coke coating, and AT4A desig-

nates the quarter-ingot of T4 from the Anderson pot with charcoal coating.

In the 1919 experiment all the sheets were given a coke coating in the same kind of pot. Four of the best-working pots were used, and eight lots were tinned in each.

ASSORTING

After tinning, the sheets were taken to the assorting room, where inspectors examined both surfaces of every sheet for defects, sorting

TABLE 24.—AVERAGE PERCENTAGE OF COKE WASTER SHEETS, 1917 EXPERIMENT.

Sheets.	Wasters.	Sheets.	Wasters.
Regular.	*Per cent.*	*Titanium-treated.*	*Per cent.*
All R_f (6 heats)	15.7	All T (6 heats)	9.7
All CR (heats 1, 2, 3)	13.9	All CT (heats 1, 2, 3)	13.1
		T (heats 1, 2, 3)	12.7

TABLE 25.—AVERAGE PERCENTAGE OF PRIME SHEETS, 1919 EXPERIMENT.

Sheets.	Primes.	Sheets.	Primes.
Regular.	*Per cent.*	*Titanium-treated.*	*Per cent.*
R	67	T	63
CR	74	CT	80
SR	59	ST	68
SCR	70	SCT	61
R and CR	70	T and CT	72
SR and SCR	65	ST and SCT	65

the sheets into four groups—"Primes," "menders," "wasters," and "waste-wasters." The primes were sheets showing no obvious defects. The menders were sheets defective because of incomplete coating, and were considered capable of being repaired by passing through the tin pots again. The wasters were sheets usable in part but containing defects which could not be remedied by re-tinning. The waste-wasters were sheets fit for nothing but scrap.

Records were kept of the number of primes, wasters, etc., for each lot in each experiment. In the 1917 experiment the coke menders were re-tinned and assorted again in the usual way, and because of the large number of uneven sized lots, this introduced serious complications in the recording of wasters and primes. In the 1919 experiment the menders were all put with the wasters. Tables in Appendix XIV give

in detail the count of primes, wasters, etc., for each separate lot in both experiments. In the 1917 experiment a true percentage of waster sheets can be obtained from these records only for the coke plate, from which the menders were re-tinned and re-assorted, and the small experimental lots must be combined with the large lots in this calculation. Table 24 gives the results obtained in this way, with the waste-wasters included among the wasters. The R and T values are each from only six heats, for one heat of each class was divided into quarter-ingot lots, which cannot be included in the average table on account of the unknown disposition of the menders. Unfortunately R3 was one of these heats, so that the average for copper-bearing regular steel from heats 1, 2, and 3 has no corresponding non-copper value with which it may be compared. The T value from heats 1, 2, and 3 should be used in comparison with CT, but the values from all six heats should be used in comparing R with T. For the 1919 experiment, Table 25 gives only the primes resulting from the first inspection. It should be understood in this case that the balance of each class of steel is composed of wasters and menders, of which a certain small number would probably be primes after re-tinning.

WASTER ANALYSES

The nature of the defects causing sheets to be classed as wasters is very important in this comparison of different steels, for only those defects due to the steel base of the sheet should be considered. Defects arising from poor practice in any step of manufacture from the sheet-mill rolling to the final tinning should be disregarded unless enough sheets are compared so that any defects not due to the character of the steel and arising from these operations are divided equally among the different classes of steel. It is doubtful if this was the case in either of these experiments. Therefore, it was advisable to separate the wasters into various groups according to the causes of their defects. Such a "waster analysis" was made on all the small experimental lots and quarter ingots of the 1917 experiment, and on a number of wasters from the large lots; also on all the wasters in the 1919 experiment. These results are tabulated in Appendix XIV; the steel defects, which are of especial interest in this case, are given in detail, while the other defects are given merely in groups. It is important to note that in the waster analysis of 1919, each defect was recorded separately, whether it was accompanied by others in the same sheet or not; thus, the total number of defects recorded exceeded the total number of waster sheets in nearly every instance.

In summarizing the waster percentages due to steel defects, the assumption was made that all these wasters were found at the first inspection and that none of them was classed among the menders. This is probably not far from the truth, as menders are supposed to be worth attempting to restore by re-tinning, and wasters due to steel defects could not, of course, be expected to improve in such treatment. Therefore, the failure to record and analyze all the mender sheets after re-tinning does not affect the value of tables 26–28, which give only the percentages of wasters or defects due to the steel base. Only the small experimental lots are covered for the 1917 experiment where the analyses refer to defective sheets; while for the 1919 experiment the values, as previously noted, refer to individual defects, and not to separate sheets. The 1919 results are therefore averaged in two ways, as percentages based on the total number of sheets, and on the total number of defects; and in each instance averages of the first three heats, whose titanium-treatment was normal, are given, as well as the general averages of all four heats.

TABLE 26.—PERCENTAGE OF WASTERS DUE TO STEEL DEFECTS IN TOTAL NUMBER OF SHEETS, 1917 EXPERIMENT.

Sheets.	Wasters.	Sheets.	Wasters.
Regular.		*Titanium-treated.*	
Coke coating:	*Per cent.*	Coke coating:	*Per cent.*
All R	5.0	All T	2.2
All CR (heats 1, 2, 3)	3.0	All CT (heats 1, 2, 3)	1.6
R (heats 1, 2, 3)	2.4	T (heats 1, 2, 3)	2.5
Charcoal coating:		Charcoal coating:	
All R	5.6	All T	3.9
All CR (heats 1, 2, 3)	3.3	All CT (heats 1, 2, 3)	2.7
R (heats 1, 2, 3)	6.0	T (heats 1, 2, 3)	3.4

TABLE 27.—AVERAGE NUMBER OF STEEL DEFECTS PER 100 SHEETS, 1919 EXPERIMENT.

Sheets.	Defects per 100 sheets.		Sheets.	Defects per 100 sheets.	
	First three heats.	All heats.		First three heats.	All heats.
Regular.			*Titanium-treated*		
R	4.5	6.1	T	2.1	12.3
CR	11.8	9.2	CT	3.5	3.4
SR	7.8	24.7	ST	13.4	11.7
SCR	11.6	14.9	SCT	4.9	8.1
R and CR	8.4	7.8	T and CT	2.8	7.9
SR and SCR	9.7	19.9	ST and SCT	9.1	9.9

TABLE 28.—PERCENTAGE OF WASTER DEFECTS DUE TO STEEL DEFECTS, 1919 EXPERIMENT.

Sheets.	Waster defects due to steel defects.		Sheets.	Waster defects due to steel defects.	
	First three heats.	All heats.		First three heats.	All heats.
Regular.	*Per cent.*	*Per cent.*	*Titanium-treated.*	*Per cent.*	*Per cent.*
R	25.1	26.2	T	12.6	44.3
CR	54.3	45.5	CT	27.9	30.3
SR	56.9	73.3	ST	51.9	49.2
SCR	58.4	62.0	SCT	19.4	29.4
R and CR	41.9	35.7	T and CT	19.0	40.3
SR and SCR	57.8	68.6	ST and SCT	35.4	38.3

The results given from the 1917 experiment indicate that, on the average, the titanium-treated steel was responsible for only about one-half or two-thirds as many waster sheets as the regular steel. Although great variation between heats is shown by the individual records given in the appendix, still a fairly definite improvement can be distinguished for the titanium steel even from these individual values. For instance, among the experimental lots only one blistered sheet was found in the titanium steel, and 32 in the regular; and only four titanium-treated ingots gave over 14 wasters due to bar scale, while eight regular ingots gave more than 14 of such wasters. The effect of the copper additions is not shown very definitely in this experiment, for while the average values given above appear to indicate a slight improvement, the individual records show an improvement for the copper-bearing steel in only half the heats, and worse results, as compared to the non-copper, in the others.

The average tables for the 1919 experiment are both subject to more or less serious objections. In Table 27, a sheet which had two or more steel defects was counted a corresponding number of times, so that there were not really as many sheets defective on account of the steel as might appear from the figures. In Table 28, the percentages depend, of course, on the total number of defects, so that they are governed more or less by the variable numbers of defects due to causes other than the quality of the steel. Still the values for the first three heats probably give a fairly correct idea of the actual results in general. In each of these heats the titanium steel was consistently better than the regular in regard to freedom from steel defects; the copper-bearing steel was worse than the non-copper in two heats and in the third heat there was little difference. The silicon-treated steel was quite irregular,

being very bad as to steel defects in some instances and good in others. In the fourth heat, the silicon-treated ingots were especially bad.

The averages for the titanium steel for all heats of the 1919 experiment are quite different from those for the first three heats, and a word of explanation seems necessary in regard to this discrepancy. By referring to the individual records in Appendix XIV, the sheets from ingot T24 are seen to have given a very bad record in regard to blisters and bar scale. That this showing is abnormal, and not due to the titanium in the steel, is indicated by the good showing of ingot CT24, for had the trouble originated in the ladle, from too large a titanium addition or some other defect in the liquid steel, T24 would not have been the only ingot to give such bad results. The true source of these defects was probably the poor surface of the mold into which this ingot was poured. The notes on the appearance of the ingots when stripped, given in Appendix IV, show that this ingot had a bad surface defect in the middle, due to a burnt mold. As the bars from which the experimental sheets were made came from the middle part of each ingot, this surface defect was undoubtedly the cause of the excessive bar scale and blisters on the finished sheets. This point should be kept carefully in mind in connection with all the waster data that include this fourth heat of the 1919 experiment, and on account of the great influence which this chance occurrence had on the average results from all the heats, it is safer to consider only the first three heats in the averages for this experiment.

SELECTION OF COMMERCIAL PLATE

There were included in this experiment some lots of tin plate which have not been described previously in this report. These were commercial open-hearth and Bessemer sheets purchased in the open market, from various mills. The different lots are described in Appendix XVIII, and the following letters are used to designate these commercial sheets: H for open-hearth; B for Bessemer; and C before either indicates copper-bearing steel. The numbers following these letters indicate order numbers, or mills, and not heat numbers as in the R and T steels. The final letters A and X designate charcoal and coke coatings, respectively, as before.

TESTING OF TIN PLATE

CHEMICAL ANALYSES

The chemical analyses on the 1917 plate included: (1) Determination of weight of tin coating on the original plate used in making the cans, and on sheets after exposure to weather in the rusting test; (2) determination of the carbon, manganese, sulphur and phosphorus content of failed cans; (3) determination of the copper content of the commercial plate.

On the 1919 plate the analyses included determination of the weight of tin coating on some of the cans, and determination of the phosphorus content of representative cans.

Four representative sheets from each ingot of the 1917 experiment, and from each lot of the commercial tin plate, with both coke and charcoal coatings respectively, were analyzed for weight of tin coating by the laboratory of the American Can Company. Each sheet was divided into twelve equal parts for this purpose, and a circular disc 4 square inches in area was taken from the center of each part as a sample. The analyses were made by the iodine method, and the results

TABLE 29.—AVERAGE WEIGHT OF TIN COATING, IN POUNDS PER BASE BOX, ON SHEETS OF 1917 EXPERIMENT.

Sheets.	Weight of coating per base box.	
	Coke.	Charcoal.
	Pounds.	*Pounds.*
R	1.43	2.13
CR	1.60	2.29
T	1.37	2.12
C	1.65	2.30
H	1.37	3.04
CH	1.61	[a]3.07
B	1.42	2.84
CB	1.51	2.50
Quarter ingot AR3	1.68	3.28
Quarter ingot AT4	1.85	1.87
Quarter ingot ER3	1.44	.....
Quarter ingot ET4	1.39	.....
Quarter ingot SR3	.....	3.84
Quarter ingot ST4	.....	3.11

[a] CH4Z omitted from this average on account of being 3A plate.

expressed as pounds of tin per base box of tin plate. The individual results are given in Appendix XV, arranged in the form of a diagram showing the location on the sheet of the samples analyzed. Table 29 gives a summary of the results on the sheets representing each class of steel of the experimental lots, and also one sheet from each of the eight quarter-ingot lots that were chosen specially for the investigation of different methods of coating.

Analyses for tin coating were also made in the same way on sheets of the 1917 experiment that had been exposed to the weather in the rusting test described in a later section of this report. These analyses for each sheet are given in Appendix XVI; and averages in Table 30 may be used to compare the coating on the sheets tested by rusting with that on the representative sheets covered by Table 29.

TABLE 30.—AVERAGE WEIGHT OF TIN COATING, IN POUNDS PER BASE BOX, ON SHEETS FROM RUSTING TEST, 1917 EXPERIMENT.

Sheets.	Weight of tin coating per base box.	
	Coke.	Charcoal.
	Pounds.	*Pounds.*
R	1.39	2.20
CR	1.51	1.95
T	1.38	2.12
CT	1.44	2.09
H	1.21	3.03
CH	1.33	[a]2.39
B	1.36	2.54
CB	1.28	2.26

[a] CH4Z omitted from this average on account of being 3A plate.

As some tin was undoubtedly lost by oxidation, solution, or flaking during rusting, somewhat lower results would be expected in this last table. There seems, however, to be fairly good agreement with the former representative table, so that the rusting tests may safely be assumed to have been made on representative material.

Determinations were made of the phosphorus, manganese, carbon, and sulphur content of about 850 perforated cans of the 1917 experiment. The analyses of the steel base of failed cans of the 1917 experiment may be compared with the sheet-bar analyses to obtain an idea as to how the failures were affected by chemical composition of the steel.

TABLE 31.—RANGE OF CARBON, MANGANESE, PHOSPHORUS, AND SULPHUR IN STEEL BASE OF FAILED CANS OF 1917 EXPERIMENT.

CARBON.

Number of samples..	23	16	23	21	20	28	51	15	32	28	24	41	39	45	62	29	31	10	28	10	70	99	49	61
Carbon content of —	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
0.09 to 0.10%	.....	.....	4	10	5	.....	.....	.....	3	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	5	.....	2	.....
.10 to .11%	4	6	22	10	10	36	.....	.....	9	.....	12	20	3	4	7	.....	.....	40	7	.....	7	6	8	3
.11 to .12%	4	6	27	10	25	32	.....	7	16	14	21	39	.....	14	11	7	16	10	14	20	32	31	24	32
.12 to .13%	44	44	17	62	35	29	18	20	22	54	50	27	15	11	19	41	29	40	36	10	35	33	39	43
.13 to .14%	39	31	26	4	25	3	29	53	44	21	17	12	36	53	31	31	32	10	36	50	15	19	27	18
.14 to .15%	9	13	.....	4	.....	.....	31	20	6	11	.....	2	23	16	19	11	20	.....	7	20	5	11	.....	4
.15 to .16%	.....	.....	.....	.....	.....	.....	18	.....	.....	.....	.....	.....	15	2	10	10	3	.....	.....	.....	1	.....	.....	.....
.16 to .17%	.....	.....	4	.....	.....	.....	4	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.17 to .18%	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....

MANGANESE.

Number of samples..	23	16	23	21	20	28	51	15	32	28	24	41	39	45	62	29	31	10	28	10	70	99	48	61
Manganese content of —	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P ct	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
0.20 to 0.21%	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	3	.....	.....	.....	.....	.....
.22 to .23%	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...
.24 to .25%	.....	6	18	15	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	1	.....	.....	20	.....	.....	.....	.....	.....	.....
.26 to .27%	.....	.....	21	42	10	11	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	40	.....	.....	.....	.....	.....	2
.28 to .29%	.....	.....	35	9	30	28	2	.....	3	18	.....	10	2	.....	1	.....	.....	10	.....	.....	.....	.....	.....	.....
.30 to .31%	13	13	13	19	30	33	25	7	9	46	42	24	17	22	.....	7	.....	.....	.....	10	5	.....	6	4
.32 to .33%	35	25	9	5	15	28	30	.....	56	11	34	30	26	32	5	11	23	20	8	30	7	.....	4	5
.34 to .35%	31	6	.....	10	10	.....	23	34	16	7	30	10	19	22	40	31	45	.....	11	50	14	4	13	15
.36 to .37%	13	37	.....	.....	.....	.....	16	46	10	6	.....	9	15	9	30	17	26	.....	21	10	20	4	30	23
.38 to .39%	4	13	4	.....	5	.....	4	7	.....	.....	.....	12	16	9	12	17	6	.....	32	.....	10	5	25	22
.40 to .41%	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	3	4	5	7	.....	.....	18	.....	14	18	12	13
.42 to .43%	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	5	7	.....	.....	3	.....	1	7	2	3
.44 to .45%	.....	.....	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	.....	.....	1	.....	.....	.. ..	4	.....	12	13	4	1
.46 to .47%	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	14	4	7
.48 to .49%	.....	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	3	.....	2	.....	.....	.....	.....	.....	.....	4	13	.....	3
.50 to .51%	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	. ...	1	16	.....	.....
.52 to .53%	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....
.54 to .55%	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.. ..	.....	.....	.....	.....	.....	....	...	.....	1	.....	1
.55 to .81%	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	. ...	.....	1

TABLE 31.—RANGE OF CARBON, MANGANESE, PHOSPHORUS, AND SULPHUR IN STEEL BASE OF FAILED CANS OF 1917 EXPERIMENT.—*Continued.*

PHOSPHORUS.

	T1.	CT1.	T2.	CT2.	T3.	CT3.	T4.	T5.	T6.	T7.	R1.	CR1.	R2.	CR2.	R3.	CR3.	R4.	R5.	R6.	R7.	H.	CH.	B.	CB.
Number of samples..	23	15	23	21	20	28	52	14	32	28	24	41	39	45	62	29	31	10	28	10	70	99	49	60
Phosphorus content of —	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
0.040 to 0.049%	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.050 to .060%	18	47	9	14	.....	4	.....	.....	.....	.....	.....	7	.....	.....	2	3	.....	.....	3	.....	1	.....	.....	.....
.061 to .070%	57	53	.....	38	10	14	2	.....	16	3	8	2	.....	.....	8	7	10	.....	7	10	1	1	2	.....
.071 to .080%	4	.....	61	28	20	22	3	7	6	7	29	5	3	.....	21	11	6	10	11	.....	9	12	12	3
.081 to .090%	4	.....	18	5	30	29	15	7	16	36	25	27	.....	.....	35	24	26	10	18	50	16	12	5	2
.091 to .100%	.....	.....	4	10	15	17	45	36	44	26	17	32	.....	7	22	20	22	30	50	20	16	30	4	28
.101 to .110%	.....	.....	4	.....	10	10	26	29	12	14	17	15	3	11	2	7	23	10	7	20	28	20	29	38
.111 to .120%	.....	.....	.....	.....	5	4	9	14	6	8	4	5	28	29	7	14	10	.....	4	.....	20	13	26	15
.121 to .130%	4	.....	4	.....	5	.....	.....	.....	.....	3	.....	5	38	27	2	11	3	30	.....	.....	9	7	14	7
.131 to .140%	.....	.....	.....	5	.....	.....	.....	7	.....	.....	.....	2	15	18	1	3	.....	10	.....	.....	.....	5	6	2
.141 to .150%	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	10	6	.....	.....	.....	.....	.....	.....	.....	.....	2	5
.151 to .160%	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....
.161 to .170%	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

SULPHUR.

Number of samples..	23	16	23	21	20	28	51	15	32	28	24	41	39	45	62	29	31	10	28	10	70	99	49	61
Sulphur content of —	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
0.020 to 0.029%	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.030 to .040%	.....	6	.....	.....	10	11	4	.....	6	53	.....	7	.....	.....	10	.....	10	10	7	.....	6	6	2	.....
.041 to .050%	13	19	9	14	35	21	45	27	13	39	46	12	.....	.....	29	17	23	.....	14	20	10	15	6	11
.051 to .060%	65	31	35	67	40	39	37	20	53	4	33	29	5	2	48	55	42	20	29	60	22	10	14	21
.061 to .070%	13	25	43	14	10	25	10	26	22	4	13	24	28	40	10	17	22	20	36	10	21	19	27	28
.071 to .080%	.....	13	13	.....	5	.....	.....	20	6	.....	4	22	39	33	2	7	3	30	11	10	24	18	25	12
.081 to .090%	9	6	.....	.....	.....	4	4	7	.....	.....	4	.....	15	22	.....	4	.....	10	3	.....	10	16	10	13
.091 to .100%	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	.....	3	13	3	1	.....	.....	.....	.....	.....	7	9	14	13
.101 to .110%	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	7	2	2

All the individual analyses are tabulated in Appendix XVII; a graded summary of the results is given in Table 31 and an average in Table 32.

TABLE 32.—AVERAGE CONTENT OF CARBON, MANGANESE, PHOSPHORUS, AND SULPHUR IN FAILED CANS OF 1917 EXPERIMENT.

Plate.	Number of analyses.	Average content of —			
		Carbon.	Manganese.	Phosphorus.	Sulphur.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
R	204	0.13	0.34	0.098	0.060
CR	116	.12	.34	.105	.065
T	194	.12	.32	.090	.054
CT	66	.12	.31	.075	.057
H	70	.12	.39	.101	.065
CH	98	.12	.45	.099	.070
B	50	.12	.38	.108	.073
CB	61	.12	.39	.107	.070

There are included in this investigation several lots of commercial Bessemer and open-hearth plate, both copper-bearing and non-copper-bearing. These represented commercial deliveries from the steel plants to the can companies, as described in Appendix XVIII. Some of the plate supplied as copper-bearing contained no copper and some of the plate supplied as non-copper-bearing was found by analysis to be copper-bearing. All data in this report regarding these lots of plate are given in accordance with their commercial designation as to copper content, and not in accordance with the copper content as shown by analysis. The results obtained with these lots of commercial plate, however, were disregarded in drawing conclusions as to the relative value of copper-bearing and non-copper-bearing plate. This was done because these lots of commercial plate were not found to be as represented.

Six lots purchased as non-copper-bearing Bessemer were found to be free from copper; of five lots bought as copper-bearing Bessemer, one was copper-bearing, one contained no copper, and three consisted of a mixture of copper-bearing and non-copper-bearing plate. Of seven lots purchased as non-copper-bearing open-hearth two were free from copper, two contained copper and three were mixtures of copper-bearing and non-copper-bearing plate; of six lots bought as copper-bearing open-hearth three were copper-bearing, one contained no copper and two were mixtures of copper-bearing plate and non-copper-bearing plate. The copper content of these lots of plate is given in Appendix XVIII.

The cans of the 1919 plate which were analyzed for weight of coating were not completely representative of every type of plate used, but they give an idea of the weight of coating obtained and also of the variation which may be expected in the weight of coating. All of this plate had a coke coating. Averages of the weight of tin coating are given in Table 33. For individual determinations see Appendix XIX.

TABLE 33.—AVERAGE WEIGHT OF TIN COATING ON CANS OF THE 1919 EXPERIMENTAL PLATE.

Plate.	Average weight of tin coating in pounds per base box.	Plate.	Average weight of tin coating in pounds per base box.
R21	1.54	T21	1.40
R22	1.53	T22	1.62
R24	1.70	T24	1.88
CR21	1.55	CT21	1.58
CR22	1.32	CT23	1.58
CR24	1.54	CT24	1.67
SR21	1.72	ST22	1.30
SR22	1.77	ST23	1.68
SR23	1.57	ST24	2.25
SR24	2.53	SCT21	1.55
SCR21	1.53	SCT22	1.44
SCR22	1.62	SCT23	1.63
SCR23	1.61		
SCR24	1.60		

For the phosphorus determinations on the tin plate of the 1919 experiment, 32 plain cans which had given satisfactory service were

TABLE 34.—PHOSPHORUS CONTENT OF TIN PLATE IN CANS OF 1919 EXPERIMENT.

Plate.	Phosphorus content.		
	Minimum.	Maximum.	Average.
	Per cent.	*Per cent.*	*Per cent.*
R21	0.038	0.066	0.055
T21	.026	.055	.041
R22	.058	.101	.079
T22	.050	.088	.069
R23	.047	.083	.068
T23	.036	.101	.065
R24	.078	.116	.100
T24	.056	.089	.078

taken from each lot of regular and of titanium-treated plate without copper or silicon, and the body and both ends of each can were tested. This made a total of about 750 determinations. The individual results of these determinations are given in Appendix XX, and a summary of them is presented in Table 34.

The average values shown here do not agree in every instance with the phosphorus content of the corresponding sample sheet bars (see Appendix V). This table shows that the regular and titanium-treated tin plate from the third heat of this experiment had practically equal average phosphorus content, while in the other heats the regular plate contained more phosphorus than the titanium-treated. The range in phosphorus content is given in Table 35.

TABLE 35.—RANGE OF PHOSPHORUS CONTENT IN REPRESENTATIVE CANS OF THE 1919 EXPERIMENTAI PLATE.

	R21.	R22.	R23.	R24.	T21.	T22.	T23.	T24.
Number of analyses	96	96	96	96	96	96	93	96
Analyses showing phosphorus content of:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
0.021 to 0.030%	.....	.....	.....	.....	3	.....	.....	.....
.031 to .040%	1	.....	.....	.....	38	.....	.....	.....
.041 to .050%	22	.....	1	.....	55	1	3	.....
.051 to .060%	58	1	14	.....	4	3	25	.....
.061 to .070%	19	2	36	.....	.....	32	43	.....
.071 to .080%	.....	5	47	1	.....	61	23	3
.081 to .090%	.....	37	2	6	.....	3	3	72
.091 to .100%	.....	54	.....	59	.....	.....	2	25
.101 to .110%	.....	1	.....	34	.....	.....	1	.....

The chemical work on tin plate, including analyses of the base plate and determinations of weight of coating, was done in the laboratory of the American Can Company.

ERICHSEN TESTS

Standard cupping tests were made with an Erichsen machine on three sheets taken at random from the best of the wasters from each lot of steel in the 1919 experiment. On each sheet one test was made at a point near an edge, one test was made at the center, and one midway between the center and edge, all points being located where there were no defects. The test consists in holding a piece of tin plate in a ring-shaped clamp and pushing a hard rounded steel plunger through the center until the bulged-out plate just begins to crack. The depth of

cup formed under these conditions gives a good measure of the ductility of the tin plate, provided the thickness is constant for all samples. With different thicknesses of the sheets the amount of cupping would normally be different, so standard values have been worked out for each gauge of sheet, and the final results of experiments are usually expressed as percentages of the particular standard for the given thickness of sample.

These Erichsen tests were made in the testing laboratory of the National Enameling and Stamping Co., and are given in detail in Appendix XXI. Table 36 gives a summary of the results for heats 21, 22, and 23, in which the titanium treatment was normal, likewise the averages of all four heats.

TABLE 36.—AVERAGES OF RESULTS OF ERICHSEN TESTS ON TIN PLATE OF 1919 EXPERIMENT EXPRESSED AS PERCENTAGE OF STANDARD VALUES.

Plate.	Average of Erichsen tests.		Plate.	Average of Erichsen tests.	
	Heats 21, 22, and 23.	All heats.		Heats 21, 22, and 23.	All heats.
Regular.	*Per cent.*	*Per cent.*	*Titanium-treated.*	*Per cent.*	*Per cent.*
R	108.7	110.1	T	108.7	108.7
CR	106.1	105.2	CT	109.4	107.1
SR	103.7	102.9	ST	108.1	105.9
SCR	106.5	104.7	SCT	103.9	101.8
R and CR	107.4	107.7	T and CT	109.1	107.9
SR and SCR	105.1	103.8	ST and SCT	106.0	103.8

BENDING TESTS

Bending tests were made on small pieces of tin plate from all the lots of the 1919 experiment, the clamps shown in Figure 32 being used. These were 1 inch wide and 3 inches long, and in using them a piece of tin plate about 5/8 inches wide was clamped firmly, half in one clamp and half in the other, with the two clamps in contact. One clamp was then held stationary while the other was rotated with the line of contact as an axis, first 90 degrees in one direction, then 180 degrees in the opposite, then 180 degrees back again, and so on until the sample separated into two parts. The number of 90 degree bends, that is 90 degrees in one direction and back to the vertical position, endured before separation constituted the result of the test. This work was done in the Physical Testing Laboratory of the Titanium Alloy Manufacturing Co.

The same sheets were tested in this way as were used for the Erichsen tests, but only the samples cut midway between center and edge were used, and the tests were made in duplicate instead of triplicate. Each of the two samples from a lot was tested twice, once parallel with the polishing scratches on the surface, and once perpendicular to them. The numbers of bends endured in these two directions were not the same, and the ratio of one number to the other is a measure of the quality of the metal. A high ratio, or approach to

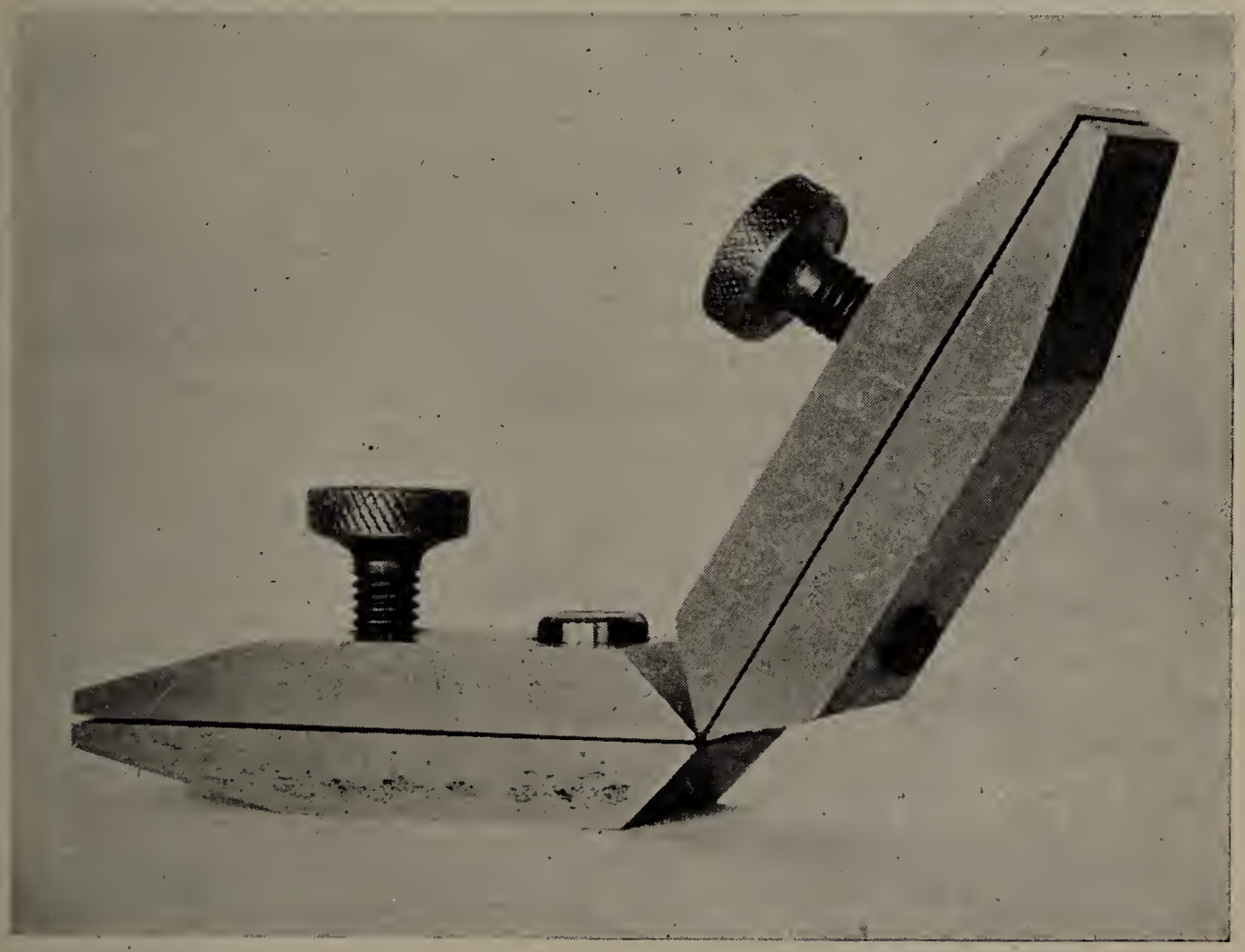


FIG. 32.—Bending clamps in use with a bend partly completed.

equality, indicates a clean and homogeneous metal, well annealed, while a low ratio or large difference indicates streaks of impurities or unevenness of structure or poor annealing. The individual results are all tabulated in Appendix XXII, and averages for the three heats whose titanium treatment was normal, as well as for all four heats, are given in Table 37.

These results show the poor quality of the silicon-treated tin plate, which has been noted before. The copper-bearing plate gave a few less bends, but about as good a ratio as the non-copper. The titanium-treated steel is not much different from the regular in regard to number

TABLE 37.—AVERAGES OF RESULTS OF BENDING TESTS, REGULAR AND TITANIUM-TREATED PLATE, 1919 EXPERIMENT.

Plate.	Number of bends.		Ratio of transverse to longitudinal results.	
	Heats 21, 22 and 23.	All heats.	Heats 21, 22 and 23.	All heats.
Regular.				
R	17.5	17.0	0.57	0.53
CR	14.0	14.5	.73	.66
SR	12.0	12.0	.49	.44
SCR	10.0	10.0	.55	.55
R and CR	16.0	16.0	.65	.60
SR and SCR	11.0	11.0	.52	.49
Titanium-treated.				
T	17.0	17.0	.68	.66
CT	15.0	16.0	.68	.62
ST	14.0	13.0	.52	.49
SCT	13.0	13.0	.62	.56
T and CT	16.0	16.0	.68	.64
ST and SCT	13.5	13.0	.57	.53

of bends but shows a slight superiority in the average ratio. By reference to the individual values in Appendix XXII, however, it appears that in one heat this difference is reversed in the non-silicon steels, so that the comparative results from this test are not especially consistent in regard to titanium treatment.

METALLOGRAPHIC EXAMINATION

Microscopic examinations of the tin plate from the 1917 experiment were made only after service tests of the cans had been completed, while in the 1919 experiment sections of tin plate were examined only before the cans were made. Enough samples were used, however, to obtain a reliable indication of the typical structure of each class of tin plate in both experiments, and in the 1917 experiment fairly extensive investigation was made of the characteristics of plate that perforated as compared with plate that gave good service in cans. The microscopic examinations, in both experiments were made only on cross-sections of the tin plate.

The material available for this work from the 1917 experiment consisted of about 110 plain (not enameled) cans, representing nearly all the different lots of regular and titanium-treated tin plate that had not failed after about 22 months' service with apples; and samples from

about 160 perforated cans, mostly enameled and representing practically all lots of plate, that had been packed with cider, strawberries, or blueberries. For the examination of typical structures, four specimens cut from ends of each of six lots of good cans, including both coke and charcoal coatings, were used; also a similar selection from the failed cans, the lots that were specially typical of good or bad service, respectively, being chosen. Seven specimens of commercial open-hearth plate and eight of Bessemer plate were also examined, and the results of the examination before and after etching are all given in detail in Appendix XXIII. Some typical structures of this tin plate are shown in Figures 33–38.

The results of this work may be summarized as follows: The regular and titanium-treated tin plate contained fewer slag inclusions than the open-hearth and Bessemer plate, the Bessemer being especially dirty; however, only failed cans of the commercial plate were examined. There was practically no difference in cleanness of steel between the good and the failed cans of the regular and titanium-treated lots examined, and neither was there any consistent difference between the structures of these two classes. All the regular and titanium-treated plate in the 1917 experiment showed coarse ferrite grains with the carbides segregated either as massive cementite or as pearlite, on account of the high temperatures at which this material was annealed. The commercial plate showed quite a variety of structure, some samples being as coarse as the experimental plate while many of them had finer structures, with the carbide more evenly distributed in a granular form.

Sixteen sections through perforations in these miscellaneous sample cans were also examined microscopically to see if any inclusions or peculiarity of structure could be recognized as associated with the failures. It is almost impossible to prove definitely in this way whether or not slag inclusions in the steel are sources of perforations, because after corrosion has progressed far enough to perforate a can, any inclusion which may have started the action is, of course, lost in the mass of rust formed. It can only be determined whether the sample seemed dirtier than usual in the general vicinity of the perforation, and, thus, what the chances were of there having been slag at the point where the perforation started. Detailed results on these sixteen samples are tabulated in Appendix XXIII. They showed in general considerably more dirty steel than the average of the other open-hearth samples examined, but only a few cases were found where corroded spots were directly associated with slag inclusions. Photomicrographs (Figures

39–44) illustrate typical instances of corrosion in connection with perforations in these cans. No marked peculiarity of structure was noticed in these perforated sections, except possibly a somewhat greater prevalence of the relief markings in the ferrite, which are due chiefly to uneven distribution of phosphorus. This may indicate a slightly higher phosphorus content at the perforated points, which is in line with deductions drawn from chemical analyses of the cans. At the same time, it should be borne in mind that the commercial Bessemer plate in which these markings were very prominent gave exceptionally good can service.

In the 1919 experiment a series of samples similar to those used for the bending tests was cut into sections for microscopic examination. Results both before and after etching are tabulated in detail in Appendix XXIII. The samples of silicon-treated steel showed more slag but less noticeable sulphides and phosphorus markings (relief markings in the ferrite) than the samples without silicon. The carbide in practically all these samples was in the fine granular form, on account of the low annealing temperatures in this experiment. Samples from SCR21 and SCT21, having been heated above 1,300 degrees F. in annealing, were exceptions to the statement above. Some of these samples, especially SR21 and SR23, showed a rough and pitted steel surface under the tin coating, which is believed to have been caused by too vigorous action of the acid in the white pickling. However, a majority of the samples in which this condition was found (SR21, SR23, T21, CT21, SR22, SCR23, ST24, and SCT24) were silicon-treated. The photomicrographs (Figures 45–51) illustrate the points that have been mentioned.

A few samples of wasters from this experiment were saved for microscopic examination of the defects, which are illustrated by several other photographs (Figures 52–54). The blisters apparently are of two kinds, the larger being caused by a long split or thin slag streak through the center of the sheet, and the smaller partly by shorter slag streaks and partly by hydrogen absorbed in pickling when the steel surface was so badly attacked and roughened. The seam in the steel of one of these wasters consisted of relatively enormous patches of oxide distributed through the center of the sheet, possibly the remnants of a pipe in the ingot. It is remarkable that these inclusions remained so thick during the rolling of the sheet.

For comparative results on cleanness or slag inclusions, and segregation between the different classes of steel within each experiment, reference should be made to the metallographic testing of the sheet bar,

FIG. 33.—Microstructure of cross-section of plate from an R2AN can from the 1917 experiment, etched with nitric acid and magnified 200 diameters, showing pearlite segregated at edges with center free from carbon.

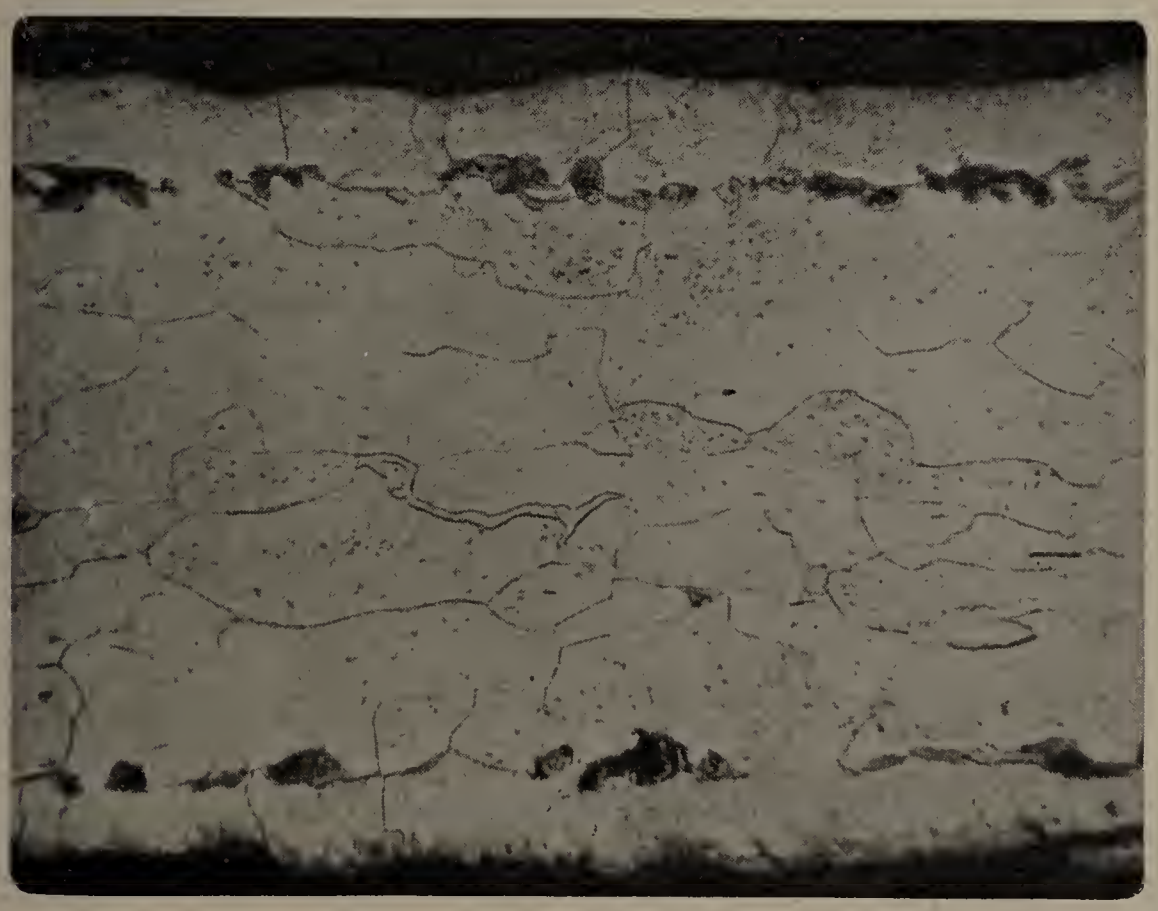


FIG. 34.—Microstructure of cross-section of plate from an R2XNN can from the 1917 experiment, etched with nitric acid and magnified 200 diameters, showing pearlite segregated at edges with massive cementite between the central ferrite grains.

FIG. 35.—Microstructure of cross-section of plate from a CR3AN can from the 1917 experiment, etched with nitric acid and magnified 200 diameters, showing very coarse ferrite grains with phosphorus markings and massive cementite between them.

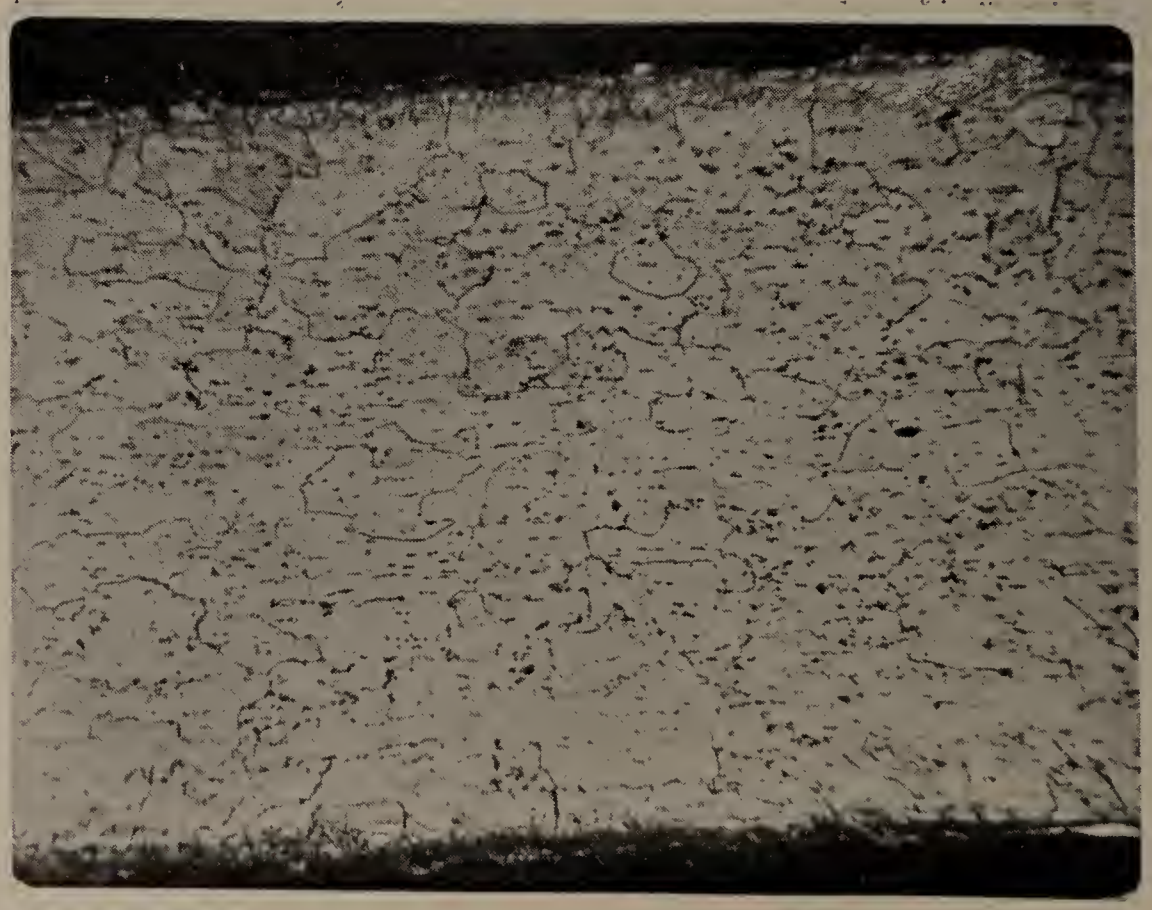


FIG. 36.—Microstructure of cross-section of plate from an H3AN can, etched with nitric acid and magnified 200 diameters, showing small ferrite grains and granular cementite in well distributed small particles.

FIG. 37.—Microstructure of cross-section of plate from an H4XNN can, etched with nitric acid and magnified 200 diameters, showing large ferrite grains, with massive cementite and pearlite near edges and carbon free center.

FIG. 38.—Microstructure of cross-section of plate from a CB3XN can, etched with nitric acid and magnified 200 diameters, showing medium ferrite grains with phosphorus markings, massive cementite, and slag inclusions.

FIG. 39.—Edge of a perforation in plate from a CR2AN can, 1917 experiment, unetched and magnified 200 diameters, showing traces of light gray slag in the steel near the black corroded spots.

FIG. 40.—Corroded spots in plate from a CR2AN can, 1917 experiment, etched with nitric acid and magnified 200 diameters, showing slag inclusions near rust at upper edge.

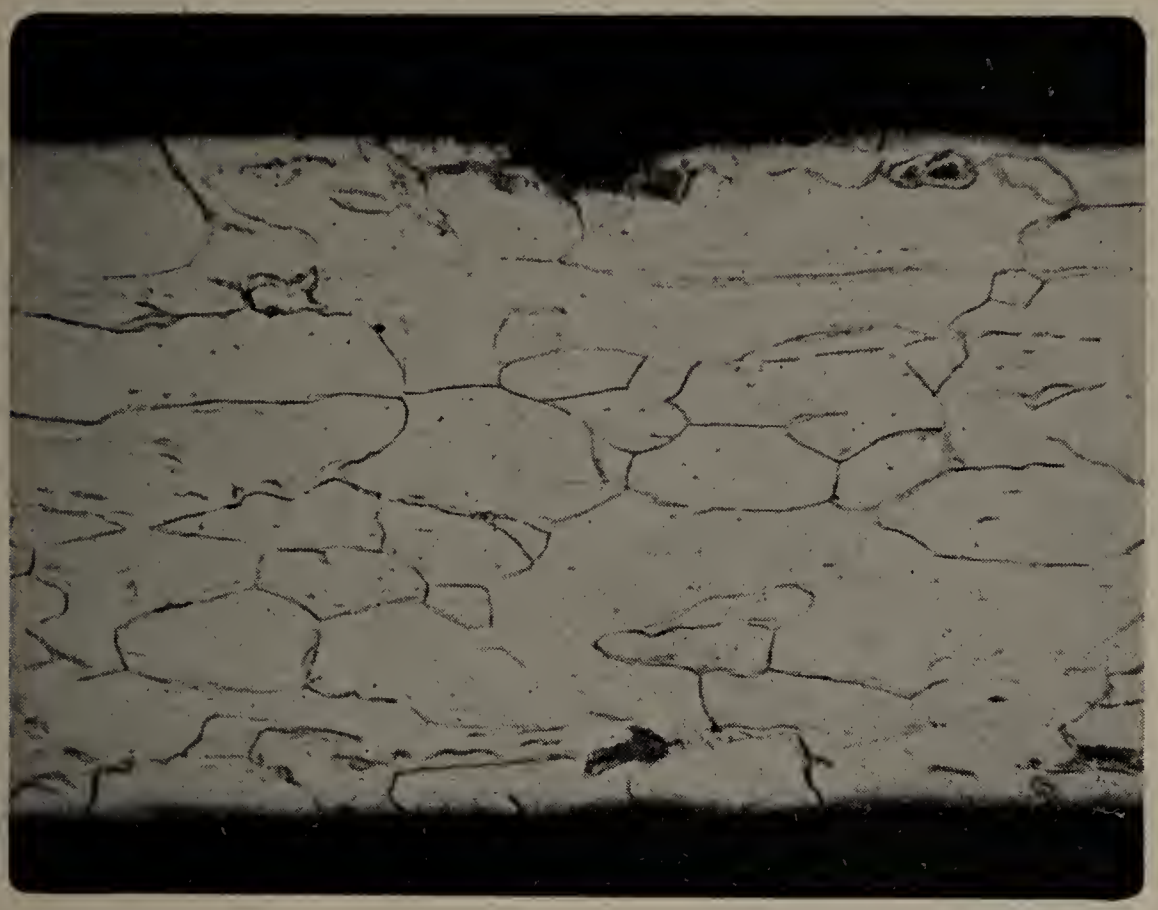


FIG. 41.—Beginning of corroded spot at a massive cementite particle close to the upper surface of plate from a CR2AN can, 1917 experiment, etched with nitric acid and magnified 200 diameters.

FIG. 42.—Corroded spots associated with thin slag or sulphide inclusions in plate from a CR2ANN can, 1917 experiment, unetched and magnified 200 diameters.

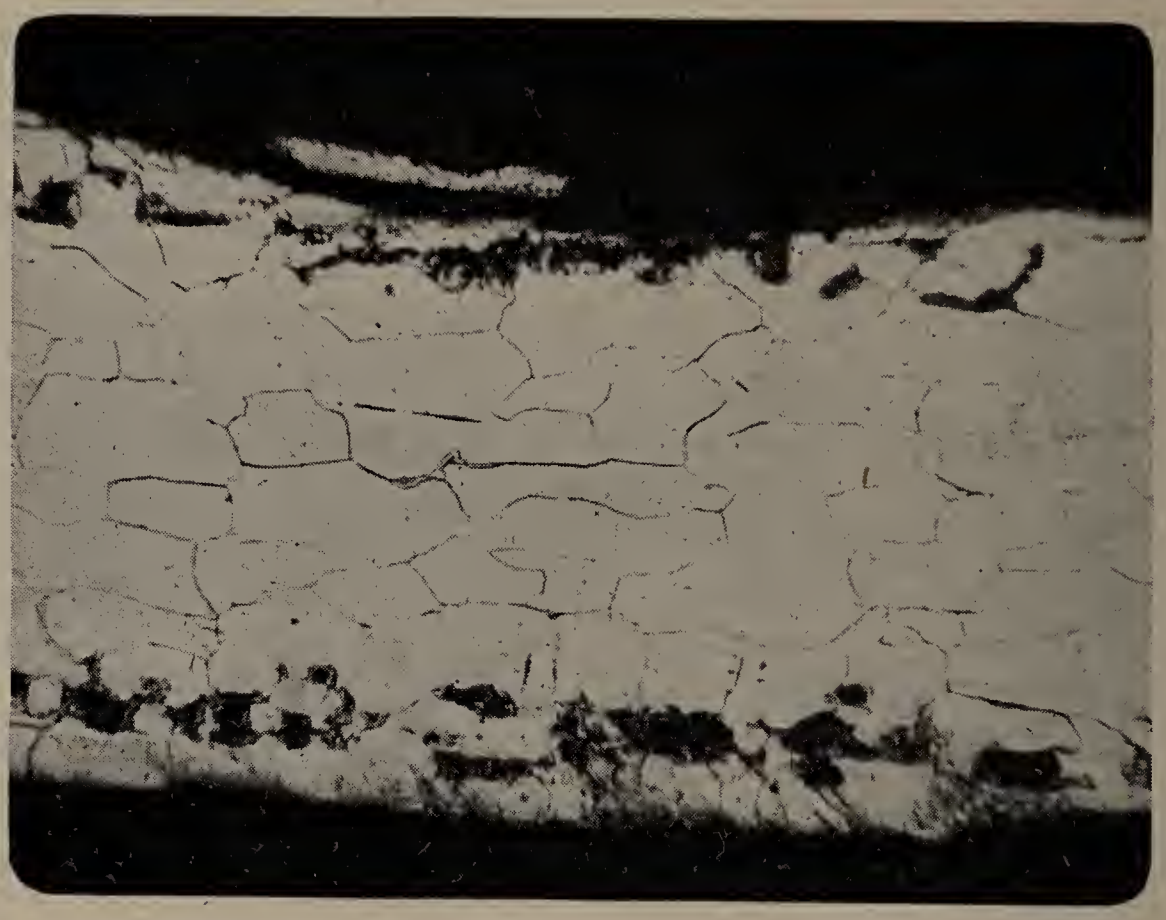


FIG. 43.—Corroded streak or crack running lengthwise through a pearlite streak near (upper) surface of plate from an AT4AN can with carbon free center, etched with nitric acid and magnified 200 diameters.

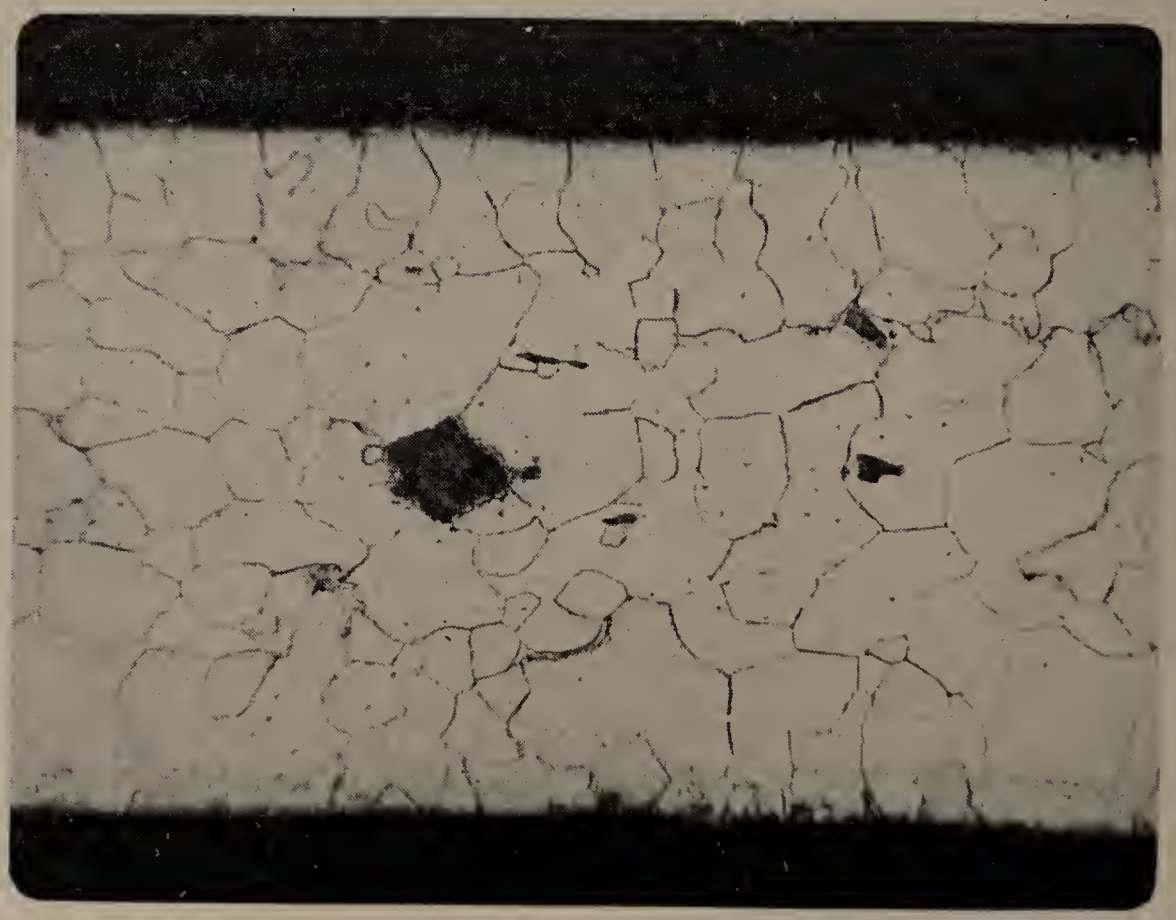


FIG. 44.—View of plate from a T6AN can not far from perforation, etched with nitric acid and magnified 200 diameters, showing no corrosion associated with the large slag inclusion in center of section.

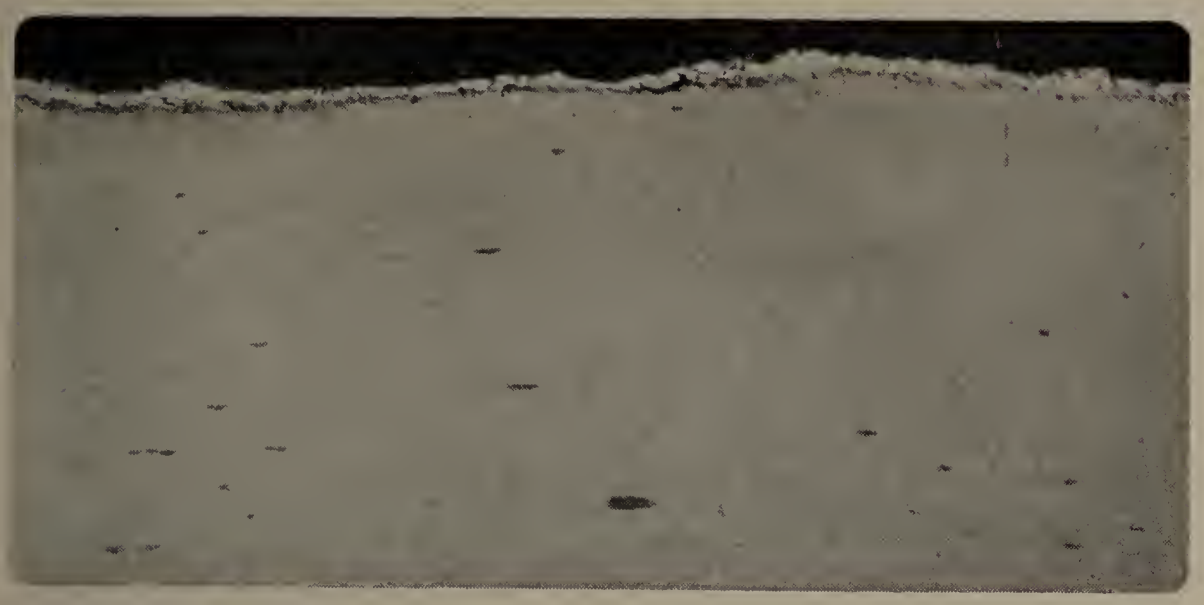


FIG. 45.—Edge of T23 tin plate from 1919 experiment, unetched and magnified 400 diameters, showing smooth steel surface and even tin coating.

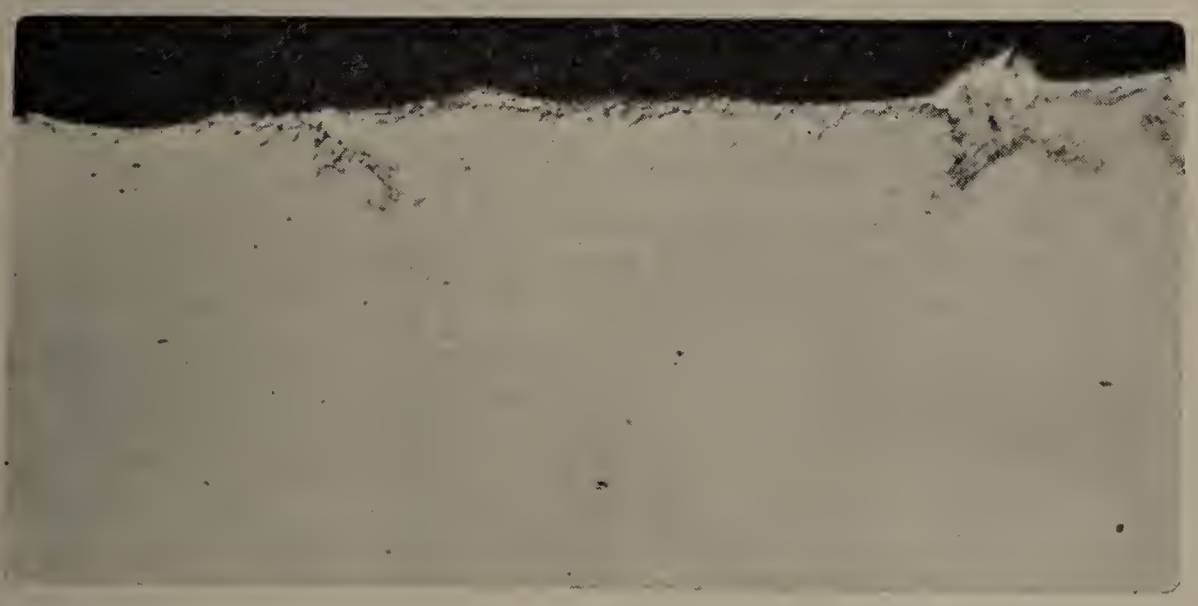


FIG. 46.—Edge of SR22 tin plate, unetched and magnified 400 diameters, showing rough and pitted steel surface with depressions in it filled with tin.

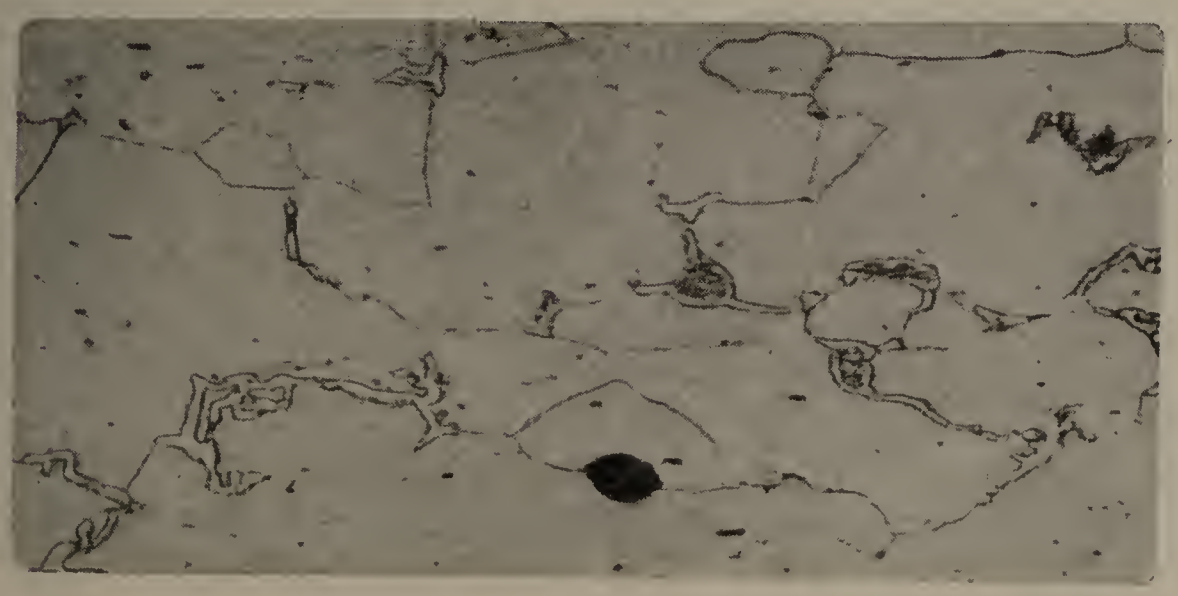


FIG. 47.—Microstructure of SCR21 tin plate, etched with nitric acid and magnified 400 diameters, showing segregated or massive carbides at the large grain boundaries, and black silicate inclusions.

FIG. 48.—Microstructure of SR23 tin plate from the 1919 experiment, etched with nitric acid and magnified 400 diameters, showing typical fine carbide specks in the elongated ferrite grains.

FIG. 49.—Surface of SR24 waster sheet with numerous small blisters, enlarged 1.5 diameters.

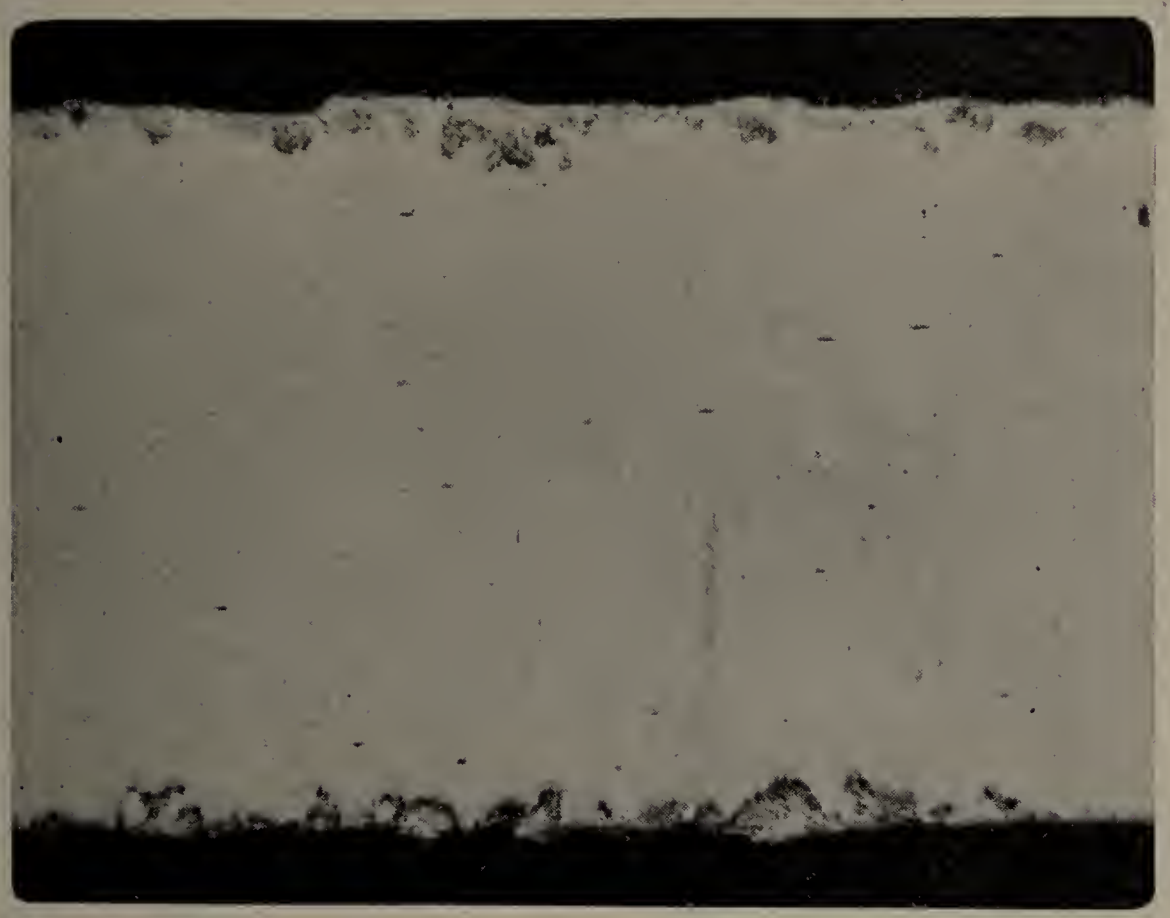


FIG. 50.—Section through sheet shown in Figure 49, unetched and magnified 200 diameters, showing very rough steel surface, with tin filling the small pits.

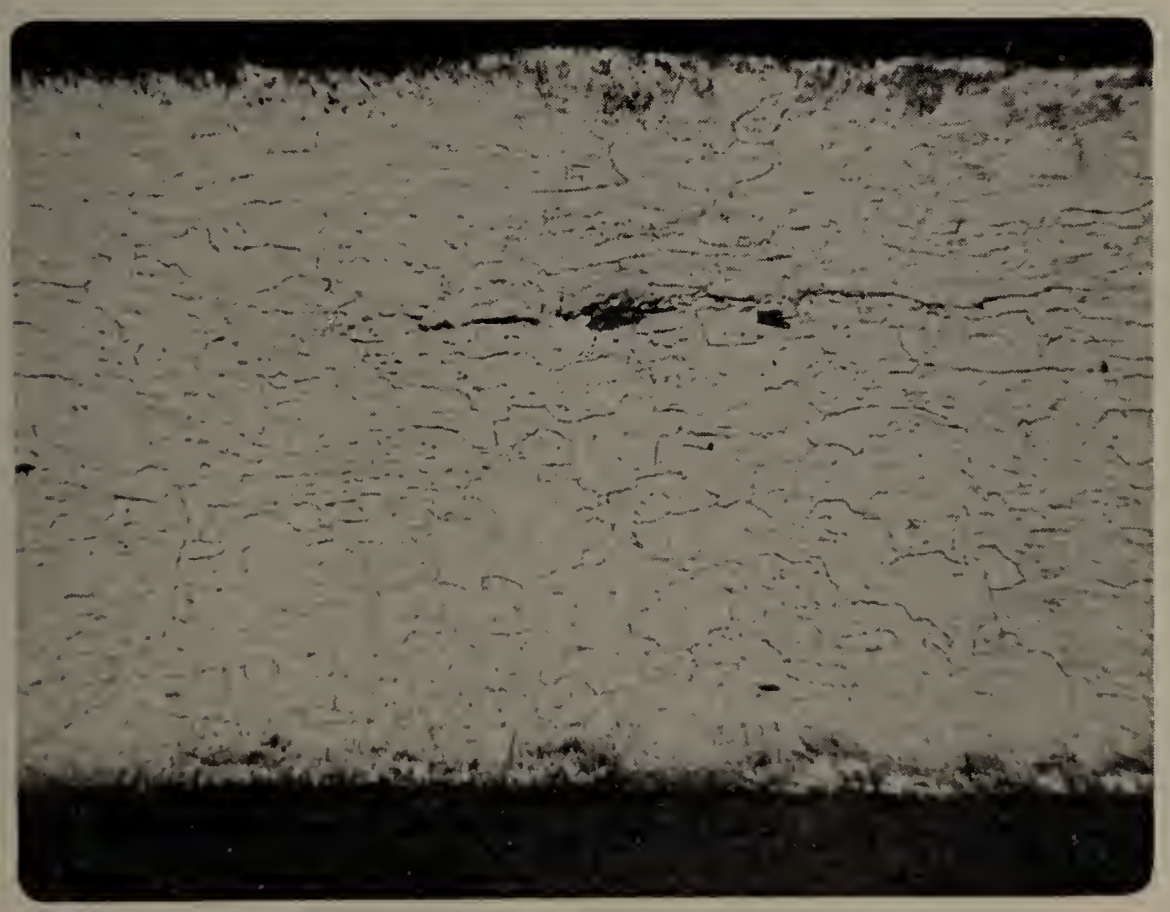


FIG. 51.—Section through sheet shown in Figure 49, etched with nitric acid and magnified 200 diameters, showing an elongated thin slag streak.

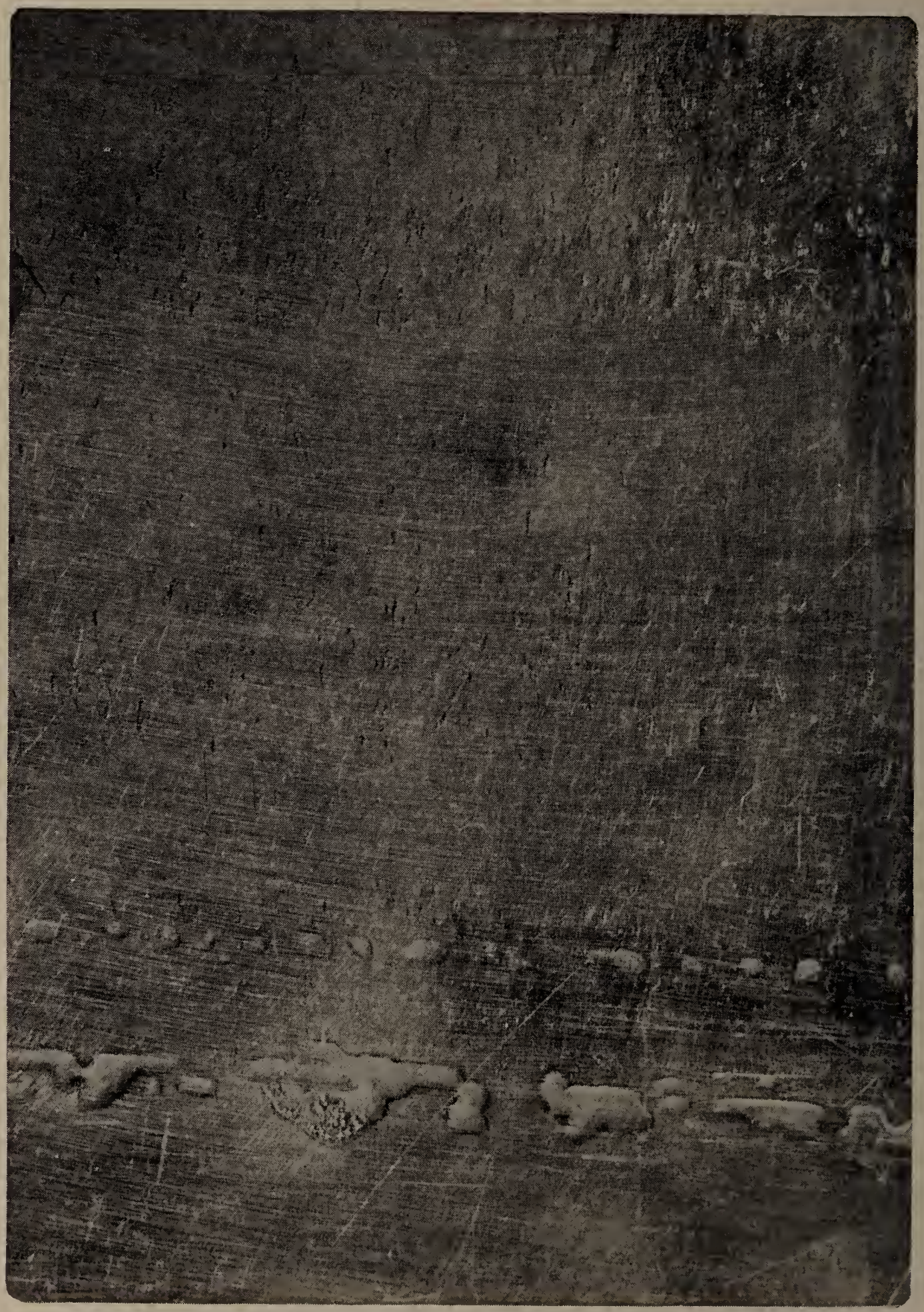


FIG. 52.—Surface of ST22 waster sheet, enlarged 1.3 diameters, showing large blisters at bottom and pits called seam in steel at top.

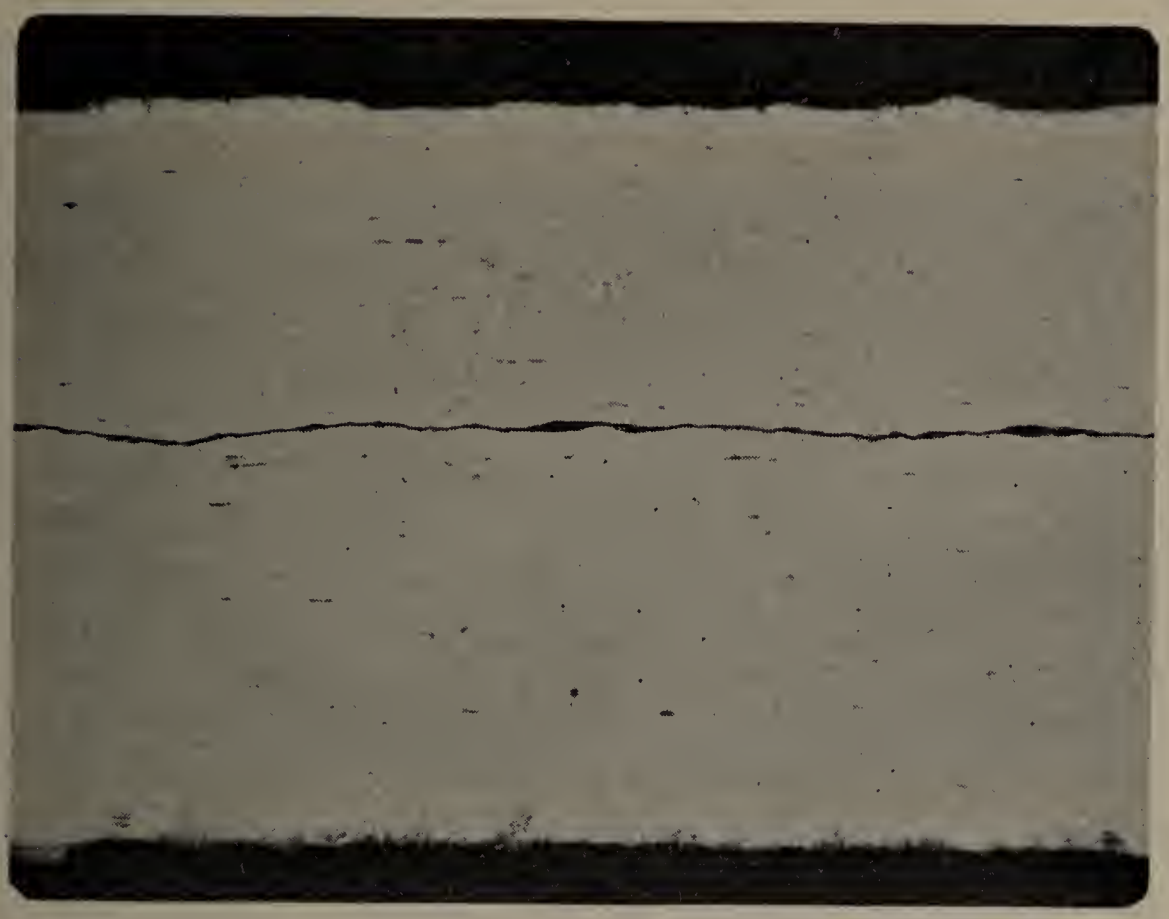


FIG. 53.—Section through large blister shown in Figure 52, unetched and magnified 200 diameters, showing very long thin streak of slag in middle of plate.

FIG. 54.—Section through "seam in steel" shown in Figure 52, etched with nitric acid and magnified 200 diameters, showing a very large oxide inclusion, with ferrite crystals distorted around it.

which is equally applicable to the finished plate in this respect, because inclusions are not changed in the steel during rolling, annealing, etc. The microscopic examinations of the tin plate were especially for the purpose of comparing the metallic structures. The important results along this line were that the experimental tin plate in the 1917 experiment had practically without exception an unusually coarse structure, with the carbide in large masses between the grains; that the commercial plate showed a various assortment of structures, from fine to coarse (as determined from failed cans); and that the plate from the 1919 experiment showed, with few exceptions, a fine structure, with the carbide evenly scattered in small specks. It was also noted that the failed cans of the commercial plate showed more slag inclusions than those of the experimental plate.

GELATINE TEST

The gelatine test was devised by Dr. W. H. Walker [1] to study the completeness of coating of tin plate. A hot solution of gelatine containing potassium ferricyanide and hydrochloric acid is poured over the tin plate and allowed to stand for twenty-four hours after solidifying. Blue spots develop which are supposed to show points where the steel base is not covered by tin.

TABLE 38.—AVERAGE GELATINE TEST GRADINGS, 1917 EXPERIMENTAL PLATE.

Plate.	Average grading.
All regular (except copper-bearing), coke and charcoal	4.2
All titanium-treated (except copper-bearing), coke and charcoal	5.2
First three heats of regular and of titanium-treated, both coke and charcoal	3.0
First three heats of copper-bearing regular and of copper-titanium, both coke and charcoal	4.7
All experimental coke-coated	3.6
All experimental charcoal-coated	5.8
All commercial non-copper-bearing open-hearth, coke and charcoal	5.8
All commercial copper-bearing open-hearth coke and charcoal	5.8
All non-copper-bearing Bessemer, coke and charcoal	5.8
All copper-bearing Bessemer, coke and charcoal	6.4
All commercial coke	5.9
All commercial charcoal	6.0

Although previous work had shown little relation between results of gelatine tests and service tests, the gelatine test was made on one sheet from each of 70 lots of the 1917 plate. The sheets were graded on the basis of the number and size of the blue spots. Those showing

[1] The Electrolytic Theory of the Corrosion of Iron and Steel and Its Applications, Jour. Iron and Steel Institute, 1909.

FIG. 55.—Results from gelatine test on coke plate.

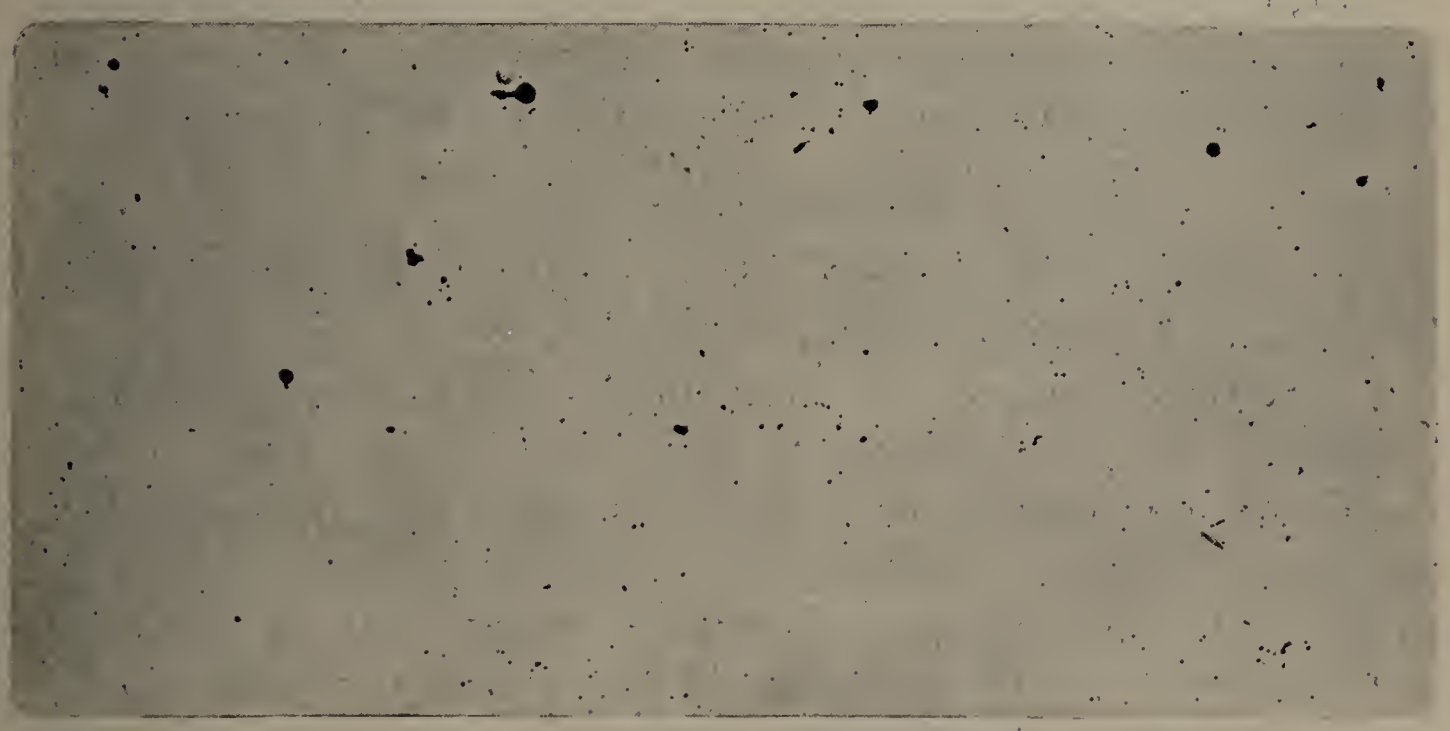


FIG. 56.—Results from gelatine test on charcoal plate.

the least amount of blue color were given a grade of 10, and those with the most a grade of 0. A summary of the results is given in Table 38. Detailed descriptions of the test and the individual results obtained are given in Appendix XXIV.

In comparing these gradings, it should be remembered that a higher gelatine grading is generally considered as indicating a more continuous tin coating.

Although the average grading is higher for the titanium-treated plate than for the regular, there is so much variation among individual gradings that the difference of the averages probably has no significance.

Not only is the average grading for the copper-bearing plate higher than that for the non-copper plate, but the grading for the copper-bearing plate of each heat is with two exceptions higher than that of the corresponding non-copper plate. (See Appendix XXIV.) There is no reason to believe that the copper-bearing plate had a more continuous coating, and it is more likely that the difference is due to a slower initial solubility of iron from the copper-bearing plate.

The individual grading for the charcoal plate of each heat is also, with two exceptions, higher than that of the corresponding coke plate.

Figures 55 and 56 show the results obtained with this test on representative coke and charcoal plate. Coke plate gives a relatively large number of spots of small area, while charcoal plate ordinarily gives a very much smaller number of relatively large spots.

RUSTING TESTS

Resistance of the plate to rusting was studied by exposing sheets of the different lots in a manufacturing district in Baltimore. Two sheets from each lot of plate were nailed to a fence and the relative rusting estimated from time to time. In grading the sheets the one showing the most rust was graded 10 and one most free from rust was graded 0. The examinations were made by from two to six members of the committee. The gradings were comparative at any particular inspection, and there was no relation between the gradings at one inspection and those at another. The amount of rust on a sheet graded 10 at the early examinations might be only enough to cause a sheet to be graded 4 or 2 at the later examinations. The marks for each examination must, therefore, be considered by themselves. The independent gradings were consistent. Averages of gradings on May 28, 1918, are given in Appendix XXV.

Two sheets from each of 71 kinds of plate studied in the 1917 experiment were exposed December 2, 1917. The rusting was very slow through the winter months. The most noticeable change on many of the sheets was the formation of a number of white spots about the size of the head of a pin.

The only marked differences throughout the period of observation between different kinds of plate were the great superiority of the charcoal over coke, both for the experimental plate and for the commercial plate, and the even greater superiority of the experimental plate over the commercial.

As a check on the results obtained through the winter months single sheets from 42 different lots were exposed March 22, 1918, and 13 sheets of ordinary commercial plate from different manufacturers were obtained from can factories in Baltimore and exposed at the same time. The plate exposed at this time rusted faster than that exposed in December. The comparatively dry weather of winter seems to have caused the rusting to proceed less rapidly than in warmer weather. At the inspection on May 28, 1918, the plate exposed March 22, 1918, showed more rust than that exposed December 2, 1917. The relative rusting of the different kinds of plate was, however, the same for the two tests. At this time some of the sheets were badly rusted. All the plate was, therefore, taken down and sent to the laboratory for determination of the weight of tin coating.

A small amount of tin was probably lost from the plates showing the most rust, but since only one side of the sheets had rusted much, and only a small proportion of the tin on this side could have been lost with the rust, the weights of coating shown by the analyses are, in general, reliable. The results for the sheets showing the most rust may be low by from 10 to 25 per cent of the total tin coating originally present. Detailed results of the analyses are given in Appendix XXV. Since the samples were taken without regard to the location of rust spots, the results show the average weights of coating and not the weight of coating at the spots where rusting occurred.

Figure 57 shows the relation between weight of coating and amount of rust for each sheet. Each small square represents one sheet. The horizontal distances represent degrees of rusting, using the average grades of May 28, 1918. In making averages "trace" was counted as 0.3 and "xx," which was the mark given to a sheet so badly covered with rust that it was considered not at all comparable with the others, was

counted as 20. Vertical distances on the diagram correspond to the weight of coating in pounds of tin per base box.

The diagram shows that weight of coating is not the sole factor in rusting, but is important. Comparatively few sheets with more than 2 pounds of tin per base box were graded worse than 1, and not very many with more than 1.4 pounds per base box were graded more than 2. Only one sheet with less than 1.2 pounds was graded better than 2, and only four with less than 1.4 pounds were graded better than 1.

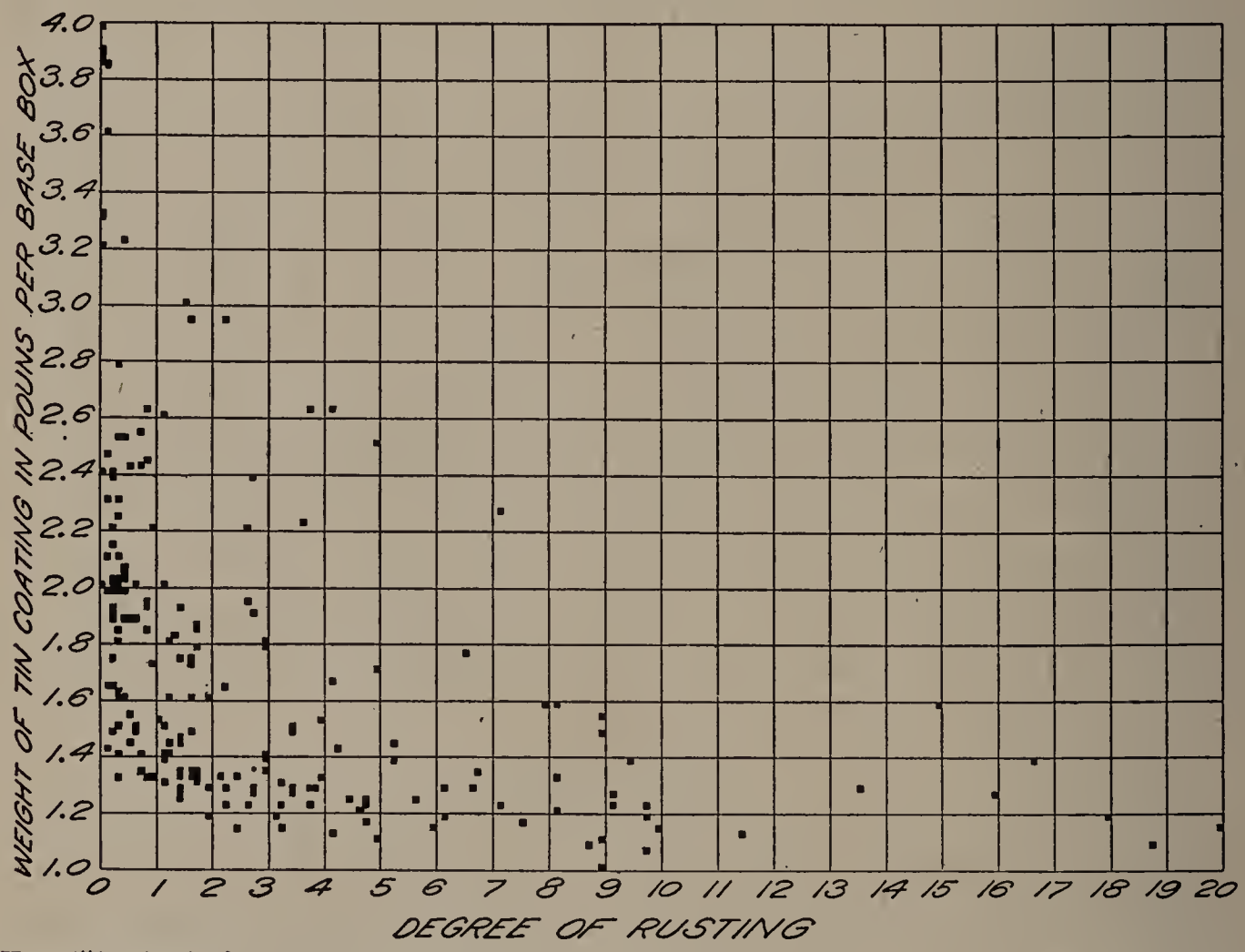


FIG 57.—Relation between weight of coating and amount of rust on each sheet.

As a further check a third set of two sheets each of 71 lots of experimental plate was exposed July 26, 1918, and graded as shown in the table of average grades in Appendix XXV. The last grading was October 24, 1918.

The relative resistance of the different types of plate was the same as in the previous exposure tests, except for the relation between copper-bearing and non-copper-bearing steels. No copper-bearing plate was exposed in the second rusting test. The first lot of experimental copper-bearing plate was much better than the experimental non-copper-bearing plate and there was no great difference between copper-bearing and non-copper commercial plate. In the plate exposed in July the experi-

mental copper-bearing plate was no better than the non-copper. More detailed comparisons of the different kinds of plate are given in Appendix XXV.

Two sheets of each of the 32 lots of 1919 plate were exposed on the same fence in Baltimore, July, 1919, and were graded for appearance of rust as shown in Appendix XXV.

The number of sheets exposed was too small to justify any general conclusions. The tin coating was not determined on the sheets exposed in this test. The weight of coating was, however, about the same as on the coke plate made for the 1917 experiment.

The appearance of the rust on the 1919 plate was different from that on the 1917 plate. Short narrow lines of rust running in one direction showed on the 1919 plate and appeared to lie in minute scratches. In order to see whether these defects brought out by rusting were due to slag inclusion in the steel or to external scratching, sections through several of the rust pits were examined. All came to points at the base, as shown in Figures 58 and 59. If they had been due to slag inclusions the bases would probably have been broader, as is indicated by the slag at the right of the rust pit in Figure 58. The 1919 plate was cleaned with peanut shells, while the 1917 experimental plate was cleaned with bran, as was probably the 1917 commercial plate.

The rusting tests, taken as a whole, indicate that many factors affect the amount of rust formed on tin plate exposed to the weather. Some of these may be the kind of steel, the finish of the base plate as determined by the pickling, annealing and cold rolling operations, the kind of cleaning material used and the quantity of oil left on the plate, and the effects on the plate of storage. These factors influence the rusting in such different but indefinite degrees that their effects have not been singled out. The one influence which consistently appeared throughout the tests was weight of tin coating. Figure 57, which includes two lots of experimental and commercial plate, brings this out clearly and the conclusion is confirmed by the action of the third lot exposed July 26, 1918, as shown in Table 97.

This conclusion refers to the relative rusting of different lots of plate exposed to the same conditions. Actual rusting of tin plate and cans is almost wholly dependent on storage conditions. In proper storage, plate with light coating will keep a long time without rusting, while plate with a heavy tin coating may rust quickly if conditions of temperature and moisture are favorable for rusting.

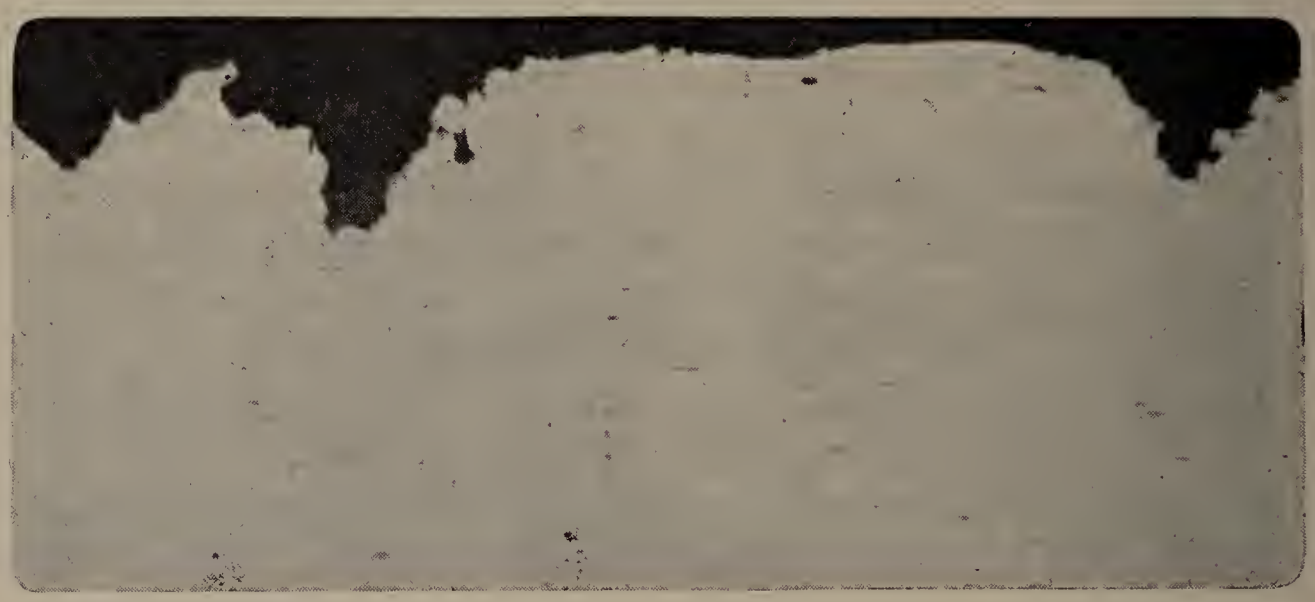


FIG. 58.—Section of plate showing three rust pits extending down into plate; magnification 200 diameters; coating not shown.

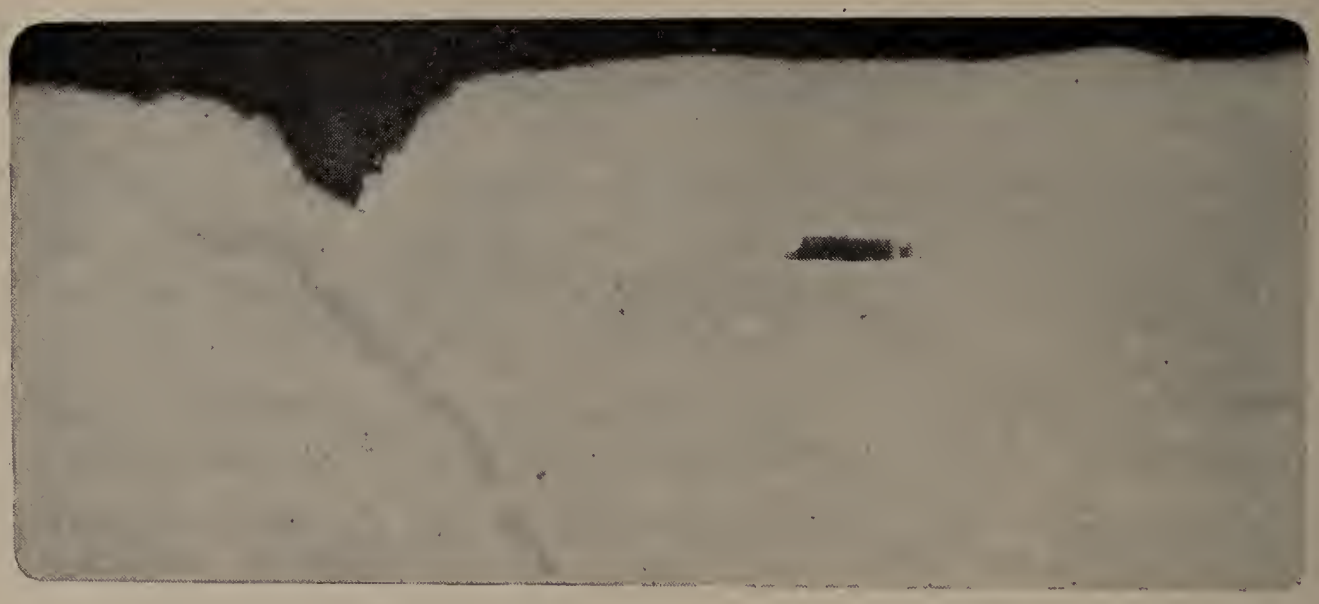


FIG. 59.—Section of plate showing a rust pit and a slag inclusion; magnification 400 diameters.

MANUFACTURE OF CANS

From each lot of the experimental plate of the 1917 and 1919 experiments and from the commercial plate of 1917 were made the desired number of No. 2 sanitary cans, $3\frac{7}{16}$ inches in diameter and $4\frac{9}{16}$ inches high.

In the 1917 experiment the sheets taken for enameled cans were coated in the usual way; alternate sheets were taken, after baking, to be used for enameled and for renameled cans, respectively. Division between enameled and renameled in 1919 was made after the sheets were slit; alternate body blanks were put together and the ends from the edge strip were used for enameled cans and those from the strip nearer the center for renameled cans.

As the sheets were slit each lot was marked. In addition to the letters, R, T, H, B, C, S, X, and A, another mark was added to cover the enameling, P was used for plain (not enameled) cans, N for enameled and NN for renameled. RIXP signified a plain can (P) with coke coating (X) on regular steel (R) from heat 1. CT3ANN signified a renameled can (NN) from plate with a charcoal coating (A) with copper-bearing steel (C) and from the titanium-treated steel (T), heat No. 3.

After the ends were stamped they were marked with process ink, dried, and then lined with paper gaskets. Body blanks were not marked. The lots of cans were made in a regular order with enough body blanks of distinctive appearance between each two lots to make it possible to change the lots of ends without interrupting the operation of the machinery and at the same time to insure proper assembling of bodies and ends.

EXPERIMENTAL PACKS

The products packed in the 1917 cans for the purpose of studying perforations were apples, cider, strawberries and blueberries. Two cases of each of the 72 lots of plain cans and one case each of enameled and of renameled were used for cider; one case of each lot of plain cans was used for apples and one case of each lot of plain, of enameled, and of renameled was used for the blueberries and strawberries. In addition, corn was packed in one case of each of the 72 lots of plain cans to see if any relation would appear between the different variables in the manufacture of the plate and discoloration of the corn. Catsup was packed in one case of each lot of cans to study perforations and the effect of the different factors in plate and can manufacture on the color, flavor and general characteristics of the catsup. Peas were packed in eight lots of plain cans made from regular steel (four coke and four charcoal), and in the same number of titanium-treated steel cans. The last three experiments were not in the original plan of the investigation, but they were included to take advantage of the opportunity to use cans of which the history was so well known.

Apples, cider, blueberries, peaches, red raspberries, and black raspberries were packed in cans from the 1919 plate. Two cases of cider in enameled cans and two cases in renameled cans of each of the 32 lots of plate were packed; two cases of apples in plain cans only were packed. For blueberries, peaches, black raspberries and red raspberries one case each of plain cans, enameled cans and renameled cans of each of the 32 lots of plate was packed. The regular procedure of the plant where the product was packed was followed as closely as possible. In order to favor perforations the cans were slightly slack filled with some products and more than the usual air space was left. Every effort was made to secure uniformity in fill of the different lots with each product. Details of packing procedure are given in Appendix XXVI.

INSPECTION OF FRUITS

STORAGE

All products were transported to Washington as soon as possible after packing and were immediately stored in a warehouse fitted especially for this purpose. The warehouse was heated during the winter months, the temperature ranging from 60°F. to 70°F. It was provided with stacks of open shelves extending from the floor to the ceiling. The stacks on the lower floor of the warehouse consisted of 24 such shelves, while the stacks on the upper floor contained 12 shelves each. Alleys between the stacks made them accessible from both sides. The width of each shelf was 6 inches and the height between shelves 5 inches. Cleats 2½ inches apart were attached to the shelves. The cans were laid on their sides on these cleats with the side seam down. The cleats held the cans in place and raised them slightly above the surface of the shelf boards. This position allowed ready observation of the entire exterior of the cans without disturbing them. Each case lot of cans was placed on the shelves in one tier or two tiers extending from the lower to the upper shelf. For example, a case of peaches of the R21 plate would occupy one tier while the next tier would be a case lot of the CR21 plate. As the temperature of a room is higher near the ceiling, this arrangement permitted the exposure of cans from each lot of plate to similar temperature conditions.

The position of each can was thus fixed and a chart was made of the shelves so that each can could be located by number and a record kept of its condition. Such a chart is illustrated in Appendix XXVII.

INSPECTION PROCEDURE

Inspection of the pack was made at intervals of one month, with two exceptions, where the interval was six weeks. Cans which had perforated were removed from the shelves; springers were marked on the ends with the date on which this condition occurred and were re-examined until perforation ensued. Perforation in most cases was evident by the oozing of juice from the opening. In many cases, however, it was found that the opening was at first so minute that either no liquid escaped or the quantity was so small as not to be readily noticeable. It was therefore the general practice to run a needle around the countersink of the can and around the expansion

rings of springers, also to investigate other suspicious-looking points with a needle.

Although no record was kept, it is estimated that at least 90 per cent of the perforations occurring in the end of the can were in the countersink. A record was kept of the number of perforations occurring in the end of the can as distinguished from the body. The percentage of the total perforations which occurred in the body of the enameled cans of the 1917 plate is given in Table 39.

TABLE 39.—PERCENTAGE OF TOTAL PERFORATIONS OCCURRING IN BODY OF ENAMELED CANS, 1917 PLATE, BY PRODUCTS AND CLASSES OF PLATE.

Products.	Experimental plate.		Open-hearth plate.		Bessemer plate.	
	Coke.	Charcoal.	Coke.	Charcoal.	Coke	Charcoal.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Blueberries	7.2	8.5	12.5	6.9	8.2	18.8
Strawberries	.4	.4	3.7	1.0	2.2	0.0
Cider	16.8	5.8	7.5	8.4	11.9	9.9
All products	7.8	5.8	6.6	5.9	7.0	9.8

In the 1917 plate no body perforations occurred in the plain cans, except in cider packed in cans made from the experimental plate, where three of a total of 125 perforations were body perforations. In the enameled cans of the 1919 plate, 85, or 2 per cent, of a total of 4,162 perforations were body perforations. No body perforations had occurred in the 1919 plain cans up to February 1, 1922.

OCCURRENCE OF SPRINGERS AND PERFORATIONS

In tables in the appendix are given the percentage of failures (cans found to be springers or to be perforated) at each inspection period for each product packed, in cans of each type of plate used; also average tables for all products. These tables include both enameled and plain cans of the 1917 pack and enameled cans of the 1919 pack. In all the data in this report as to the service value of cans, enameled and renameled cans are combined under the term enameled.

At the time this report was written there had not been sufficient perforations in the plain cans of the 1919 experiment to warrant including any data in regard to them.

Charts have been constructed from the data in the tables, each chart illustrating one of the tables. The numbers at the bottom of these

charts indicate the time in months since the packing of the products. The numbers at the left side indicate the percentage of failures. The point at which the curve starts is the last inspection date at which there were no failures. For instance, in Figure 60, it is shown that slightly more than 25 per cent of the enameled cans containing peaches had either perforated or reached the springer stage 7.5 months after packing, while only about 5 per cent of the enameled cans containing blueberries had either perforated or formed springers in the same time.

Relation of Springers to Perforations.

Under the term failures are included, first perforation of the cans due to the action of the acid of the product and, second, hydrogen springers, that is, springers due to hydrogen gas generated by the action of the acid of the product upon the plate. When a can became a hydrogen springer it generally perforated in a short time, so that the percentage of cans which at any given time were springers only was generally small. The relative percentage of perforations and springers at each inspection date in the enameled cans of the 1919 experiment is given in Appendix XXVIII, and the corresponding charts. In Figure 60 this comparison is made for each product for which the regular plate alone was used; in Figure 61, results for all types of plate (regular, copper-bearing, titanium and copper-titanium) are averaged together for each product; in Figure 62 is an average both of plates and of products.

These curves reveal that at any given time the springers were only a small part of the total failures, the relative percentage varying with different products. From Figure 61 it will be noted that the relative percentage of springers at any time was largest in peaches and smallest in black raspberries. Figure 61 is also of interest in showing the comparative time at which failures commenced with the different products, and the comparative rapidity with which they proceeded. Failures in cider commenced somewhere between 3 and 4.5 months after packing and proceeded very rapidly; those in peaches commenced between 5 and 6.5 months after packing and proceeded relatively slowly. Red raspberries showed no failures at the end of 19.5 months of storage.

It should not be inferred that failures with these products always occur in the order indicated. In coke-coated enameled cans of the 1917 experimental pack failures in cider commenced 5.5 months after packing; in blueberries, between 3.5 and 4.5 months after packing, thus reversing the order for these products in the two experiments. As

stated under experimental packs, these fruits were packed under conditions favoring perforation, that is, they were slack filled and in most instances no exhaust was given. Under packing conditions where the cans are well filled and where a good exhaust is given, the rate of perforation should be much slower.

As stated above, the data give the relative number of springers and perforations at each inspection date, but do not show separately the percentage of cans which had become springers and then perforated at or before a specified inspection date. For instance, at the end of 10 months of storage a certain number of cans were springers and a much larger number had perforated. Of these perforated cans, some had become springers before perforation was observed and others had perforated without having gone through the springer stage. Tables 40 and 41 show, for each kind of experimental plate in the 1917 and 1919

TABLE 40.—NUMBER AND PERCENTAGE OF PERFORATED ENAMELED CANS, 1917 PLATE, RECORDED AS SPRINGERS BEFORE PERFORATION.

Products and plate.	Cans recorded as springers.	
	Number.	Per cent of total perforated cans.
Cider.		
All plate	493	39.6
Regular plate, total	293	42.2
Coke coating	172	45.4
Charcoal coating	121	38.4
Titanium-treated plate, total	200	36.2
Coke coating	126	44.0
Charcoal coating	74	27.6
Blueberries.		
All plate	301	18.7
Regular plate, total	176	22.0
Coke coating	87	20.8
Charcoal coating	89	23.2
Titanium-treated plate, total	125	15.4
Coke coating	45	10.8
Charcoal coating	80	20.3
Strawberries.		
All plate	97	6.4
Regular plate, total	52	6.8
Coke coating	26	6.7
Charcoal coating	26	6.8
Titanium-treated plate, total	45	5.9
Coke coating	25	6.2
Charcoal coating	20	5.5

TABLE 41.—NUMBER AND PERCENTAGE OF PERFORATED ENAMELED CANS, 1919 PLATE, RECORDED AS SPRINGERS BEFORE PERFORATION.

Products and plate.	Cans recorded as springers.	
	Number.	Per cent of perforated cans.
Cider.		
All plate	1,079	40.1
Not deoxidized with silicon, total	136	9.6
Regular plate	48	6.8
Titanium-treated plate	88	12.4
Deoxidized with silicon, total	943	64.0
Regular plate	483	65.2
Titanium-treated plate	460	63.0
Blueberries.		
All plate	293	29.1
Not deoxidized with silicon, total	28	6.2
Regular plate	21	7.6
Titanium-treated plate	7	4.0
Deoxidized with silicon, total	265	47.7
Regular plate	152	47.6
Titanium-treated plate	113	47.7
Peaches.		
All plate	367	53.2
Not deoxidized with silicon, total	70	24.4
Regular plate	57	28.0
Titanium-treated plate	13	15.7
Deoxidized with silicon, total	297	73.7
Regular plate	183	81.0
Titanium-treated plate	114	64.4
Black Raspberries.		
All plate	126	12.7
Not deoxidized with silicon, total	6	1.3
Regular plate	6	2.3
Titanium-treated plate	0	.0
Deoxidized with silicon, total	120	23.1
Regular plate	74	25.4
Titanium-treated plate	46	20.1

NOTE.—In the 1919 plate, under "regular" are included both regular and copper-bearing; under "titanium" are included both titanium and copper-titanium.

experiments, the number of perforated cans recorded as springers prior to perforation; also the percentage they constituted of the total perforated cans of each kind of plate. These tables do not include all cans which had been springers before perforating. When a can became a springer and perforated the same month only the latter condition was recorded, so that the only springers of which a record was made were

those in this condition at one inspection period which were found perforated at some later inspection period.

These tables reveal that the percentage of cans that were once springers varies with the different products and with the different types of plate used for the same product. For cider the percentage is high in both the 1917 and 1919 packs, being 39.6 and 40.1 per cent, respectively. For blueberries the percentage in both instances is lower than that of cider but differs considerably in the two packs.

Relation of Titanium Treatment of the Steel to Failures.

Figures 63-71, derived from tables in Appendix XXIX, present a comparison of the failures in cans made from the 1917 regular experimental plate with those in cans made from the 1917 titanium-treated plate. As previously stated there were manufactured seven heats of the regular experimental steel and seven heats of the titanium-treated steel. In no case were regular plate and titanium-treated plate prepared from the same heat, as was done in the 1919 experiment. There were thus 14 distinct heats. As was discovered later, there was considerable difference in the service value of cans made from different heats of steel which were as similar in composition as they could be made under commercial factory conditions and which were manufactured in as uniform a manner as was practicable under these conditions. Notwithstanding these differences, it was felt that the number of heats used was sufficiently large that, by comparing the average failures of seven regular heats with the average failures of seven titanium-treated heats, definite conclusions could be drawn in regard to the effect of titanium. This method of comparison has been used in Figures 63-71. In order that a comparison might also be made of the service value of the two weights of coating used, they were placed on the same chart. In making this comparison, it should be borne in mind that the average difference between the weights of coating on the coke and the charcoal plate was approximately 0.7 pound per base box, which is less than the difference between the average commercial coke and charcoal plate.

By means of these charts the failures may be compared in two ways: (1) by the percentage of failures in cans of two or more types of plates at some specified time, and (2) by the times at which some specified percentage of failures occurred. For instance, in Figure 63, apples in plain cans, it is shown that failures commenced first with the titanium-treated coke plate sometime after 5.5 months of storage. The percentage at this time, however, is insignificant. At 9.5 months, the failures

with the regular coke plate were 6.5 per cent, with the titanium-treated coke plate, 2.4 per cent. At 12.5 months they were 14.9 and 2.4 per cent; at 16.5 months, 30.3 and 13.1 per cent, and at 20.5 months, 37.5 and 20.8 per cent, respectively. On the basis of the time required to reach a definite percentage of failures, regular coke cans reached the figure of 10 per cent at about 11.5 months, while the titanium-treated coke plate did not reach this percentage until about 16 months after packing, a difference of about 4½ months in favor of the latter. At 20 per cent, there was a difference of about 4¾ months. A similar comparison can be made of the regular charcoal with the titanium-treated charcoal, or of the coke coating of each type of plate with the corresponding charcoal coating.

From Figures 63-67, it is evident that in plain cans titanium treatment was more effective in preventing failures than an increase in tin coating of 0.7 pounds per base box, while in the corresponding enameled cans (Figures 68-71), the increased weight of coating was more effective than the titanium treatment.

For every product of the 1917 pack titanium treatment increased the service value of the plate, except with strawberries in charcoal-coated enameled cans, where there is a very slight difference (Figure 70) in favor of the regular.

The difference in time at which failures reached 10 and 20 per cent in the regular and in the titanium-treated plate of the 1917 experiment is given in Table 42, the differences in time being obtained from Figures 63-71, inclusive.

Figures 72-101 show the relation of titanium treatment to the percentage of failures in the 1919 experiment. On each chart is a curve representing the service value of the cans made from regular steel of one particular heat, and for comparison with it the curves representing the service value of cans from titanium-treated steel, copper-bearing steel and copper-titanium steel of the same heat. In addition to the charts for individual heats for each product, charts showing the average of all four heats of each type of steel for each product are given.

The results obtained in the 1919 experiment are strictly comparable, since from each heat were prepared regular steel, titanium-treated steel, copper-bearing steel, and copper-titanium steel, and they are alike except in so far as they may have been changed by the titanium treatment, by the copper, or by both. Thus, we do not have the possible variation due to difference in heats as in the 1917 experiment. As noted on page

38, silicon was used in some of the molds as a deoxidizer, that is, one of each of the ingots of the steels was treated with silicon. There were in all, therefore, eight different types of steel from each of four heats from which plate was made. The service value of the silicon plate was very poor, as may be seen from Figures 109 and 110. For this reason,

TABLE 42.—TIMES AT WHICH FAILURES REACHED 10 AND 20 PER CENT, RESPECTIVELY, IN CANS OF THE REGULAR AND TITANIUM-TREATED PLATE, 1917 EXPERIMENT.

Products and plate.	Time at which failures reached 10 per cent in cans of regular plate.	Additional time for failures to reach 10 per cent in cans of titanium-treated plate.	Time at which failures reached 20 per cent in cans of regular plate.	Additional time for failures to reach 20 per cent in cans of titanium-treated plate.
Plain cans:				
Coke coating —	*Months.*	*Months.*	*Months.*	*Months.*
Apples	11½	4½	15½	4¾
Cider	15¾	4¾	17¼	3+
Blueberries	12¾	2	14¼	2
Strawberries	(a)	(a)	(b)	(b)
Average, all products	14¼	2½	16½	3+
Charcoal coating—				
Apples	12¼	5	16¼	4½+
Cider	15	5½	19¼	1+
Blueberries	12¾	2	14¾	1½
Strawberries	(a)	(a)	(b)	(b)
Average, all products	16¾	2¾	(b)	2+
Enameled cans:				
Coke coating —				
Cider	6½	1½	7¾	1½
Blueberries	4¾	¾	5½	½
Strawberries	4¾	¾	6¼	1
Average, all products	5¼	½	6	¼
Charcoal coating—				
Cider	7¾	2¼	9¾	2½
Blueberries	5½	¼	5¾	¾
Strawberries	5¾	(c)	7¾	0
Average, all products	6	½	7	½

[a] Failures did not reach 10 per cent.
[b] Failures did not reach 20 per cent.
[c] Difference of one-half month in favor of regular plate.

and also because the silicon plate showed such a large number of wasters (see page 86), it was not considered worth while to prepare tables and curves for the individual products for which this plate was used, although average curves are given. Since only coke coating was used, no comparison of different grades of coating is given in these charts.

TABLE 43.—TIMES AT WHICH FAILURES REACHED 10 PER CENT IN ENAMELED CANS OF THE REGULAR AND TITANIUM-TREATED PLATE, 1919 EXPERIMENT.

Products.	Time at which failures reached 10 per cent in cans of regular plate.	Additional time for failures to reach 10 per cent in cans of titanium-treated plate.	Time at which failures reached 10 per cent in cans of copper-bearing regular plate.	Additional time for failures to reach 10 per cent in cans of copper-titanium plate.
Cider:	*Months.*	*Months.*	*Months.*	*Months.*
Heat 21	5½	1¼	6¼	¾
Heat 22	4¾	¼	6	1
Heat 23	5¾	¼	7¾	¾
Heat 24	3½	1	5¾	1
Average, all heats	4¾	½	6	1
Blueberries:				
Heat 21	10¾	7	9¼	3
Heat 22	9	2¼	8¾	1¾
Heat 23	11	¾	11	¾
Heat 24	6¾	5¼	6¾	3¾
Average, all heats	8¾	3	8¾	2¼
Peaches:				
Heat 21	9½	8+	10¾	7+
Heat 22	5½	2¼	11	1
Heat 23	9½	3	[a]	[a]
Heat 24	5½	4	10¾	4
Average, all heats	6	3	11¼	4
Black raspberries:				
Heat 21	13¼	½	11¾	1¼
Heat 22	11¾	½	11½	½
Heat 23	12¾	1	13	¼
Heat 24	11½	¼	11½	½
Average, all heats	11¾	½	11¾	½
Average of all products:				
Heat 21	[b] 8¼	1½	[b] 8¾	1½
Heat 22	[b] 6¾	1	[b] 8¾	1
Heat 23	[b] 8¾	¾	[b] 10½	¾
Heat 24	[b] 6	2	[b] 7¾	2
Average, all heats	[b] 7¼	1½	[b] 8¾	1½
Average of all products in cans of silicon-treated plate:				
Heat 21	[b] 5¾	2¾	[b] 6½	2½
Heat 22	[b] 5½	¼	[b] 6	3½
Heat 23	[b] 7	[c]	[b] 10¼	¾
Heat 24	[b] 5½	0	[b] 8¾	0
Average, all heats	[b] 5¾	¼	[b] 7	2½

[a] Failures did not reach 10 per cent in cans of either plate.
[b] From average date of packing.
[c] Difference of one-half month in favor of the regular plate.

In making comparisons as to the effect of titanium treatment, the regular plate should be compared with the titanium-treated and the copper-bearing regular with the copper-titanium. If this is done by use of Figures 72-101, it will be noted that in practically every case the titanium-treated steel showed fewer failures. In Figure 73 there is little difference in service value between the regular and the titanium-treated plate, although failures started later in the latter.

In Figure 84 the copper-bearing regular is better than the copper-titanium in regard to the time of occurrence of the first failures; in Figure 89 there is practically no difference between the copper-bearing regular and copper-titanium; in Figure 99 the regular is better than the titanium until 45 per cent of the cans have failed. In every other case the titanium-treated is better than the regular.

Table 43 shows the difference in time at which failures reached 10 per cent in the regular and titanium-treated plate. Table 44 gives similar data for times at which failures reached 20 per cent. These differences in time were taken from Charts 72-101.

The times for "Average, all heats," as given in tables 43 and 44, will not be the average of the difference of time for the individual heats. The average difference is obtained from the average curves and the points at which these curves cross the 10 and 20 per cent lines at any particular time are determined by the average percentages of failures at this time and not by the average of the times at which the curves for the individual heats cross the 10 and 20 per cent lines.

With the exception of heat 23 of the silicon-treated plate (see Figure 99), where the regular plate is the better, the difference is in favor of the titanium-treated in every instance.

Another way of comparing the titanium-treated plate with the untreated plate is to determine what percentage of the total area of the charts (by total area is meant the area back to the date of packing, which for lack of space is not shown in the charts) is included in the area above the curve (this area also extending back to the date of packing). This may be called the percentage of service value at the end of the inspection period. It is entirely different from the percentage of failures in that it is a figure which represents a combination, or rather a product, of the two factors, percentage of failures and time. Suppose, for an extreme instance, that failures commenced with one type of plate four months after packing and proceeded uniformly at such a rate that at the end of eight months the percentage of failures

TABLE 44.—TIMES AT WHICH FAILURES REACHED 20 PER CENT IN ENAMELED CANS OF THE REGULAR AND TITANIUM-TREATED PLATE, 1919 EXPERIMENT.

Products.	Time at which failures reached 20 per cent in cans of regular plate.	Additional time for failures to reach 20 per cent in cans of titanium-treated plate.	Time at which failures reached 20 per cent in cans of copper-bearing regular plate.	Additional time for failures to reach 20 per cent in cans of the copper-titanium plate.
Cider:	*Months.*	*Months.*	*Months.*	*Months.*
Heat 21	5¾	1¼	6¾	1
Heat 22	5	½	6½	1
Heat 23	6	½	8½	1½
Heat 24	4¼	1	6¼	1
Average, all heats	5¼	½	6¾	1
Blueberries:				
Heat 21	11½	7+	11½	1¾
Heat 22	9½	2½	9½	1½
Heat 23	11½	¾	11½	½
Heat 24	8½	4½	8	3
Average, all heats	10	3	9¼	2½
Peaches:				
Heat 21	10½	7+	12½	5+
Heat 22	6	2¼	11¾	3½
Heat 23	10¼	7+	(a)	(a)
Heat 24	5¾	4	12¾	4
Average, all heats	7	3¼	13¼	4+
Black raspberries:				
Heat 21	15½	2¾	12¼	2
Heat 22	12¼	1	12	½
Heat 23	14½	2	14¼	0
Heat 24	11¾	½	11¾	1
Average, all heats	12¼	¾	12	1¼
Average of all products:				
Heat 21	[b] 9½	1½	[b] 9¾	1½
Heat 22	[b] 7¾	1	[b] 9¾	¾
Heat 23	[b] 9¾	1	[b] 11¾	¾
Heat 24	[b] 6¾	3	[b] 8¼	2
Average, all heats	[b] 8¼	1¾	[b] 9¾	1
Average of all products in cans of silicon-treated plate:				
Heat 21	[b] 6¼	3	[b] 7¾	2
Heat 22	[b] 5½	½	[b] 6¾	3½
Heat 23	[b] 8	(c)	[b] 11	1¼
Heat 24	[b] 6	0	[b] 9½	0
Average, all heats	[b] 6	½	[b] 8½	2

[a] Failures did not reach 20 per cent in cans of either plate.
[b] From average date of packing.
[c] Difference of one-half month in favor of regular plate.

was 50, while with another type of plate failures starting at six months also reached 50 at eight months.

Figure 102 illustrates such a case. In this figure the percentage service value may be readily calculated by dividing the area above the

TABLE 45.—SERVICE VALUE OF CANS MADE FROM REGULAR PLATE AND FROM TITANIUM-TREATED PLATE, 1917 EXPERMENT, AVERAGE OF ALL HEATS.

Products and plate.	Service value.	
	Coke.	Charcoal.
	Per cent.	*Per cent.*
Apples in plain cans:		
Regular	87.8	91.2
Titanium-treated	95.2	97.7
Cider in plain cans:		
Regular	93.5	93.9
Titanium-treated	98.3	98.7
Cider in enameled cans:		
Regular	57.7	70.2
Titanium-treated	67.7	80.6
Blueberries in plain cans:		
Regular	88.5	89.4
Titanium-treated	92.5	93.3
Blueberries in enameled cans:—		
Regular	37.6	49.6
Titanium-treated	41.9	56.8
Strawberries in plain cans:		
Regular	98.0	99.5
Titanium-treated	98.8	99.2
Strawberries in enameled cans:		
Regular	44.1	49.1
Titanium-treated	48.5	53.0
Average of all products in plain cans:		
Regular	93.1	94.1
Titanium-treated	97.1	97.7
Average of all products in enameled cans:		
Regular	48.4	58.3
Titanium-treated	55.0	64.8

curve by the total area of the chart. This gives a percentage service value of 87.5 for the plate represented by curve A and 93.8 for that represented by curve B. This represents an extremely simple case. With the curves with which we are dealing it becomes somewhat com-

plicated to calculate the areas above the curves. These areas were therefore measured by means of a planimeter and the percentage service value for the various products up to the end of the inspection period

TABLE 46.—SERVICE VALUE OF ENAMELED CANS MADE FROM DIFFERENT LOTS OF EXPERIMENTAL PLATE, 1919 EXPERIMENT.

Product and plate.	Heat 21.	Heat 22.	Heat 23.	Heat 24.	Four heats.
Cider.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Regular	44	42	46	36	42
Titanium-treated	55	42	57	41	49
Copper-bearing	49	57	74	64	60
Copper-titanium	56	61	82	62	66
Blueberries.					
Regular	84	69	79	63	74
Titanium-treated	98	85	88	90	90
Copper-bearing	80	61	79	55	70
Copper-titanium	90	76	87	79	83
Peaches.					
Regular	84	50	80	46	65
Titanium-treated	99.7	69	95	77	85
Copper-bearing	86	86	99	87	89
Copper-titanium	98	94	99	95	96
Black raspberries.					
Regular	93	76	89	71	82
Titanium-treated	95	85	94	76	87
Copper-bearing	78	76	90	72	79
Copper-titanium	90	79	91	79	85
All above products.					
Regular	78	60	75	55	67
Titanium-treated	88	73	84	73	80
Copper-bearing	74	72	86	69	75
Copper-titanium	84	78	90	79	83
All products in cans of the silicon plate.					
Regular	57	39	59	45	46
Titanium-treated	79	49	60	50	59
Copper-bearing	62	50	82	67	69
Copper-titanium	79	77	86	69	78

calculated as indicated above. These are given in Tables 45 and 46 for the 1917 and 1919 experiments.

There is but one instance where the percentage of service value favors the non-titanium-treated steel. This is for heat 24 with cider,

where the percentage for copper-bearing regular plate is slightly higher than that for copper-titanium. In two other cases the figures are the same. In all other instances the titanium-treated steel has the higher figure.

Comparison of Failures in Commercial and Experimental Plate of the 1917 Experiment.

Figures 103–106, inclusive, give a comparison of the experimental plate with the commercial Bessemer and open hearth. The figures in the tables are averages both of the lots of plate used and of the products. It will be seen that with one exception where the difference is insignificant, the commercial plate was better than the experimental. The service value of the different lots of plate, calculated in the manner previously described, is given in Table 47.

Table 47.—Service Value of Cans of Bessemer, Open-hearth, Regular, and Titanium-treated Plate, 1917 Experiment.

Cans and plate.	Per cent.
Plain cans, coke coating:	
Bessemer	96.5
Open-hearth	95.5
Regular	93.1
Titanium-treated	97.1
Plain cans, charcoal coating:	
Bessemer	99.1
Open-hearth	99.3
Regular	94.1
Titanium-treated	97.7
Enameled cans, coke coating:	
Bessemer	61.9
Open-hearth	60.2
Regular	48.4
Titanium-treated	55.0
Enameled cans, charcoal coating:	
Bessemer	86.8
Open-hearth	87.2
Regular	58.3
Titanium-treated	64.8

The average weight of coating on the commercial coke plate was somewhat lower than that of the experimental plate, while the average weight of coating on the commercial charcoal plate was higher than that on the experimental charcoal plate.

Relation of Copper Content of Steel to Failures

Three lots of copper-bearing plate were used, viz., experimental copper-bearing plate and commercial copper-bearing plate in 1917, and experimental copper-bearing plate in 1919. In both experiments copper-bearing and non-copper-bearing plate were made from the same heats of steel and should be alike except for the difference in copper content. The terms non-copper-bearing and copper-bearing as used in this report are merely relative. No experimental steel was made that was absolutely free from copper, on account of the impossibility of obtaining copper-free material for the furnace charge. Some of the 1917 experimental non-copper steel contained as much as 0.1 per cent of copper, while the copper-bearing contained about 0.4 per cent. The non-copper steel of the 1919 experiment averaged about 0.06 per cent of copper, while the copper-bearing contained approximately 0.3 per cent except heat 1, which contained only about 0.1 per cent. In 1917 copper-bearing and non-copper-bearing steel were made from six heats out of fourteen. Three of the six were regular steel and three titanium-treated steel. In 1919 copper-bearing plate was manufactured from all four of the heats, a copper-bearing ingot of regular steel, a copper-bearing ingot of titanium steel and similar ingots treated with silicon being produced from each heat.

In 1917 the results obtained by the use of copper are inconsistent. With a given product cans made from copper-bearing plate of one heat gave better service than cans from the non-copper-bearing plate of the same heat. With the same product in cans from another heat the reverse might be true. This is illustrated by Figure 107, "Cider in enameled cans, coke coating." With heat 1 of the regular plate the copper-bearing is better than the non-copper-bearing plate. With heat 2 there is little difference, and with heat 3 the non-copper is the better. Another illustration is seen in Figure 108, "Strawberries in enameled cans, coke coating." With heat 1 of the titanium-treated plate the copper-bearing is better than the non-copper-bearing plate; with heats 2 and 3 the non-copper is better. Similar inconsistencies appear with other products packed in experimental copper-bearing and non-copper-bearing plate in 1917, as will be seen by consulting the tables in Appendix XXXV.

For the effect of the use of copper in the 1919 experiment reference should be made to Figures 72-101, where the non-copper regular may be compared with the copper-bearing regular and the titanium-treated with the copper-bearing titanium-treated. The results here are more consistent between heats than in 1917, but are inconsistent with refer-

ence to products. With cider in enameled cans the copper-bearing plate consistently gave better service; with blueberries the non-copper plate was consistently better. With peaches in enameled cans copper-bearing plate, with the exception of one heat of the titanium-treated plate, was the better. Results with black raspberries in enameled cans were not consistent, non-copper-bearing plate in general giving slightly better service than copper-bearing.

No definite conclusion in regard to the effect of copper can be drawn from a comparison of the commercial copper-bearing plate with the commercial non-copper-bearing plate. For detailed results on the different lots of commercial copper-bearing plate reference should be made to Appendix XXXV.

Effect of the Use of Silicon in the Mold as a Deoxidizer.

As previously stated, some steel was made in the 1919 experiment with silicon used in the mold as a deoxidizer.

Figures 109 and 110 give a comparison of plate made of steel deoxidized with silicon in the mold with that not so treated. The comparison is decidedly in favor of the latter. The silicon-treated steel was of such a nature that it could not be manufactured into plate without considerable loss. From both manufacturing and service standpoints the use of silicon in the molds as a deoxidizer does not seem advisable.

Relation of Weight of Tin Coating to Failures.

Different weights of coating were studied in the 1917 experiment only.

Figures 111 and 112 show the effect of different weights of coating. The three lots of plate represented in Figure 111 were all made from the same steel ingot and therefore presumably were of the same composition and had the same treatment. The weight of coating was, therefore, the only variable to which can be ascribed the difference in service value. The figures given for the weight of coating are averages of 48 determinations; the individual determinations appear on pages 228–234. Likewise, in Figure 112 the only variable is the weight of coating, the steel being taken from the same ingot, which was a titanium-treated one instead of regular steel as in Figure 111.

For further study of the effect of weight of coating, reference may be made to Figures 63-71, inclusive, where the regular coke plate may be compared with the regular charcoal plate. Similar comparisons may

be made for the titanium-treated plate. The average weight of coating on these lots of plate was as follows:

	Pounds per base box
Regular, coke	1.44
Regular, charcoal	2.13
Titanium-treated, coke	1.37
Titanium-treated, charcoal	2.12

These figures show an average difference in weight of coating of 0.69 pound per base box between the regular coke and regular charcoal, and 0.78 pound between the titanium coke and titanium charcoal. The figure given above for each weight of coating is the average of 336 determinations; individual figures are given in Appendix XV.

The percentage service value as determined in the manner stated on page 130 may be used as a means of comparing the enameled cans of the coke-coated plate of each heat of the 1917 experiment with the cans of the corresponding charcoal plate. The data in Table 48 were obtained from Figures 63-71, which give the average of all products in enameled cans of each heat.

TABLE 48.—SERVICE VALUE OF COKE AND CHARCOAL-COATED PLATE OF THE 1917 EXPERIMENT AS DETERMINED FROM AVERAGES FOR ALL PRODUCTS IN ENAMELED CANS.

Plate.	Service value.		Plate.	Service value.	
	Coke.	Charcoal.		Coke.	Charcoal.
Regular.	*Per cent.*	*Per cent.*	*Titanium-treated.*	*Per cent.*	*Per cent.*
R1	56	74	T1	72	87
R2	35	44	T2	64	74
R3	59	67	T3	65	75
R4	41	49	T4	44	50
R5	65	74	T5	44	52
R6	43	46	T6	46	54
R7	39	53	T7	49	60

It will be noted that in each instance the charcoal coating gave the higher service value although there is considerable variation in the difference between the figures for the two coatings with different heats.

EFFECT OF TYPE OF POT USED IN TINNING.

Three different types of pots were used in tinning the plate of the 1917 experiment. The coatings obtained in the different pots were not of the same weight and there was no variation in the service value of

the plate that could not be ascribed to the difference in the weight of coating rather than to the type of pot used in tinning.

Variation in the Service Value of Cans Made From Plate of Different Heats.

Plate made of steel from different heats which were as nearly uniform in composition and treated as similarly as is practicable under commercial conditions varied considerably in their value for canning acid products. This is illustrated in Figures 113 to 120, inclusive.

In Figure 113 is given a comparison of the failures in coke-coated plate made from the seven different heats of the 1917 regular steel. They fall into two groups; 1, 3 and 5 gave much better service than 2, 4, 6, and 7.

Table 49.—Service Value of Enameled Cans From Different Heats of the 1919 Plate.

Heats.	Regular.	Titanium-treated.
	Per cent.	*Per cent.*
Heat 21.....	78	88
Heat 22.....	60	73
Heat 23.....	75	84
Heat 24.....	55	73

In Figure 114 the same heats with a charcoal coating show again two groups with the same heats in each group as in the coke-coated plate.

Figure 115 gives a comparison of the coke-coated plate from the seven titanium-treated heats. Although these are numbered similarly to the regular plate, the similarly numbered heats of the two have no relation to each other; that is, there is no more relation between two No. 1 heats of the two steels than there is between No. 2 of the one and No. 7 of the other.

In Figure 115 we again find two groups, with heats 1, 2 and 3 in the group giving the better service, and 4, 5, 6 and 7 in the other group. These same two groups appear in Figure 120, which is a comparison of the different heats of the charcoal-coated titanium-treated plate.

Table 48 may also be advantageously used to compare the different heats. In the 1917 experimental plate there is a range of from 39 per cent to 65 per cent in the service value of enameled cans from the different heats of the regular coke-coated plate; from 46 per cent to 74 per cent in enameled cans of the regular charcoal plate. Similarly, there

is a range of 44 to 72 per cent in the service value of enameled cans from the titanium-treated coke-coated plate and of 50 to 87 per cent in the charcoal-coated plate.

In the 1919 experiment we also find a difference in the various heats, as can be seen from a study of Figures 117 to 120. Heats 21 and 23 are better in every instance than heats 22 and 24. This can also be seen from a comparison of the percentage service value as secured from these charts, and shown in Table 49. The same relation between heats is shown by the copper-bearing plate, both regular and titanium-treated, as is shown by the non-copper.

Comparison of the Different Lots of Commercial Plate of the 1917 Experiment.

Figures 121-124 give a comparison of the different lots of commercial plate used in the 1917 experiment. These represent for each lot the average of all products in enameled cans. The average weight of coating on these different lots is given in Table 50.

A study of these charts shows that in general the charcoal plate is superior to the coke plate although the curves indicating the service value of the different lots are not always in the same order as would be expected from the weights of coating which are given in Table 50.

Table 50.—Average Weight, in Pounds Per Base Box, of Tin Coating on Different Lots of Commercial Plate.

Plate.	Weight of coating per base box.			
	Bessemer.	Copper-bearing Bessemer.	Open-hearth.	Copper-bearing open-hearth.
Coke:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Lot 1	1.22	1.61	1.45	1.54
Lot 2	1.23	1.28	1.38	1.26
Lot 3	1.47	1.65	1.39	1.68
Lot 4	1.56	....	1.27	....
Charcoal A:				
Lot 1	2.70	2.14	2.27	3.25
Lot 2	2.98	2.87	3.09	2.53
Lot 3	....	....	3.77	....
Charcoal 3A:				
Lot 4	....	....	....	3.44

Each of the above figures is the average of 48 determinations; for individual figures see Appendix XV.

This is especially true in Figure 122, where the two lots of charcoal plate show no better service than the coke. This indicates what has also been shown in the comparison of the service value of different heats, viz., that there are other factors than the weight of coating which influence the service value of the plate. As has been stated on page 93, the lots of plate represented by the curves in 122 and 124 did not in all instances have the copper content which their designation would imply.

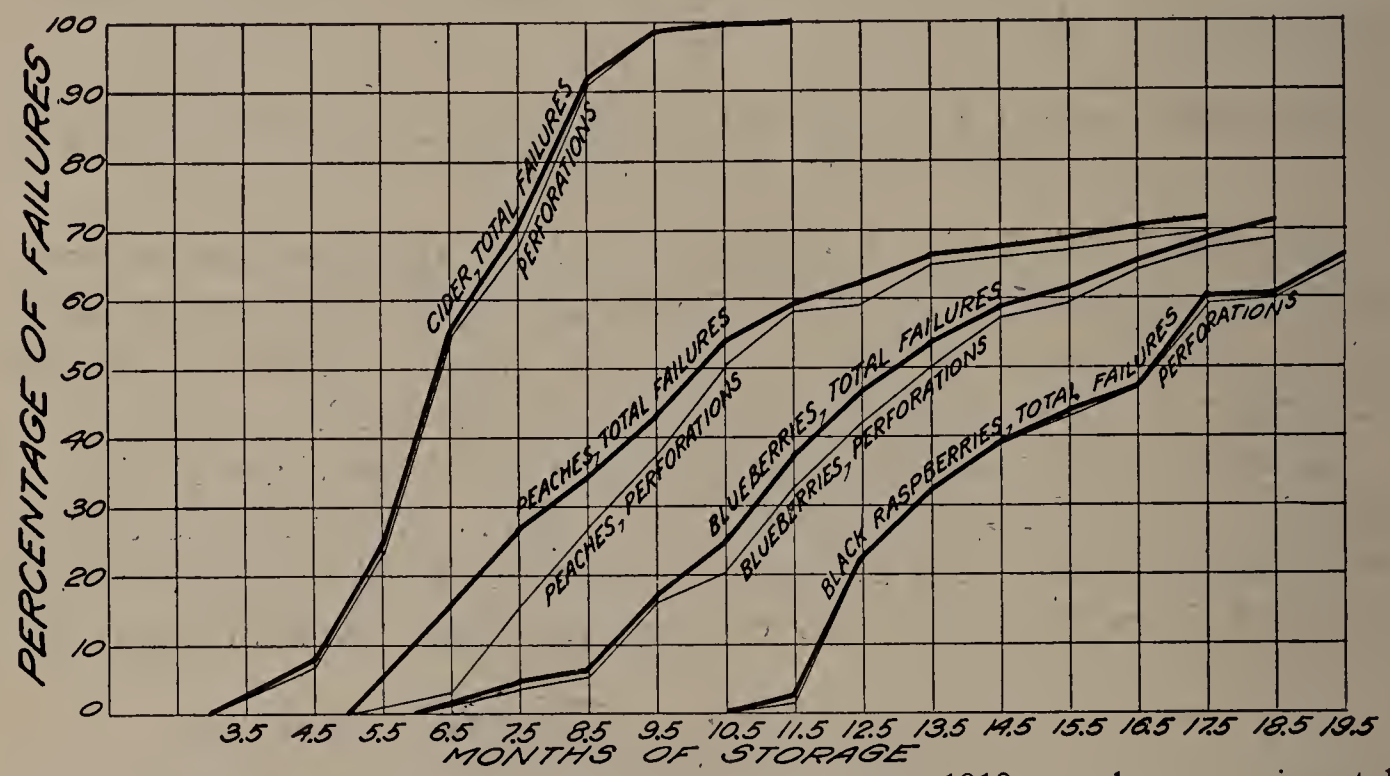


FIG. 60.—Relation of total failures to perforations, 1919 regular experimental plate; average of all heats, enameled cans (Table 102).

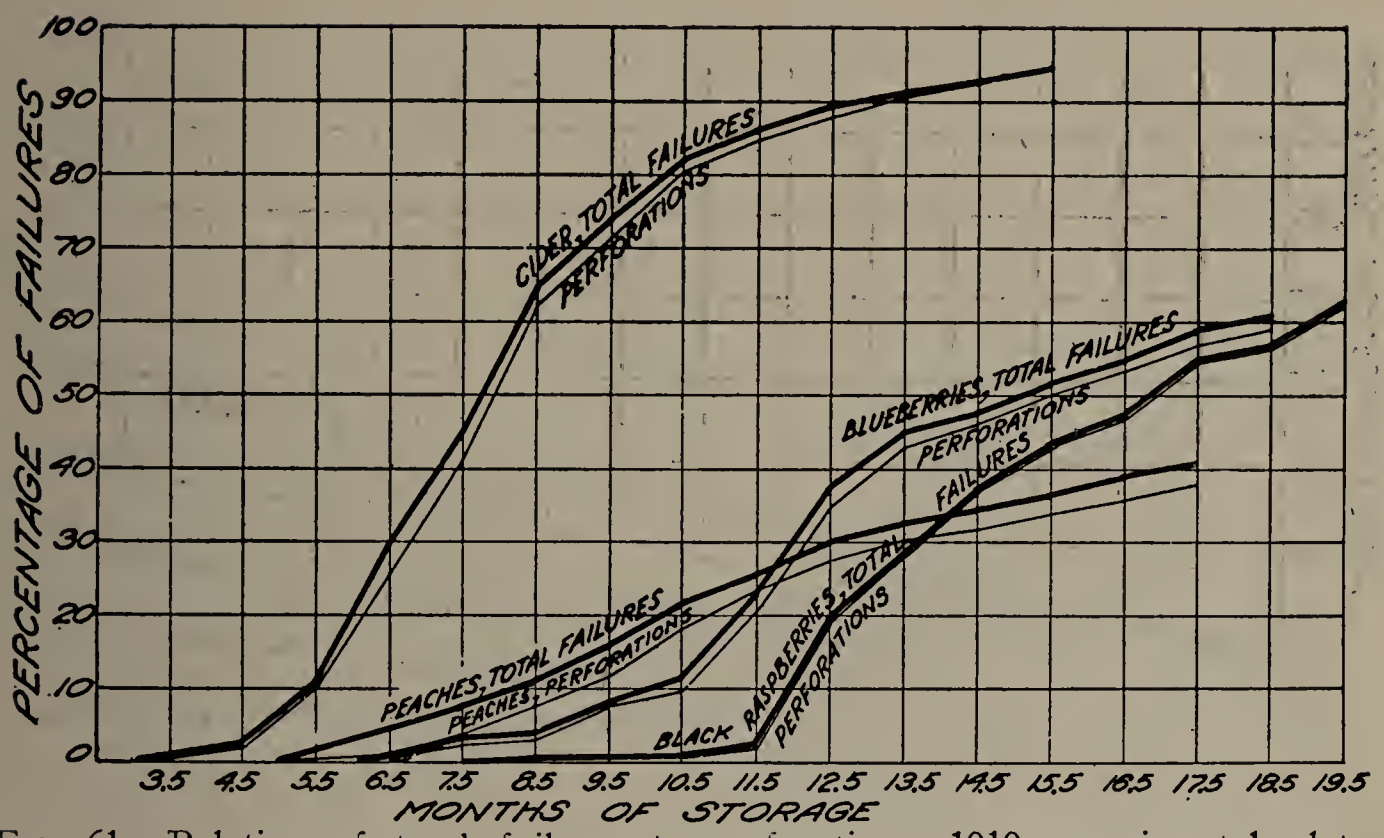


FIG. 61.—Relation of total failures to perforations, 1919 experimental plate; average of all plate, enameled cans (Table 103).

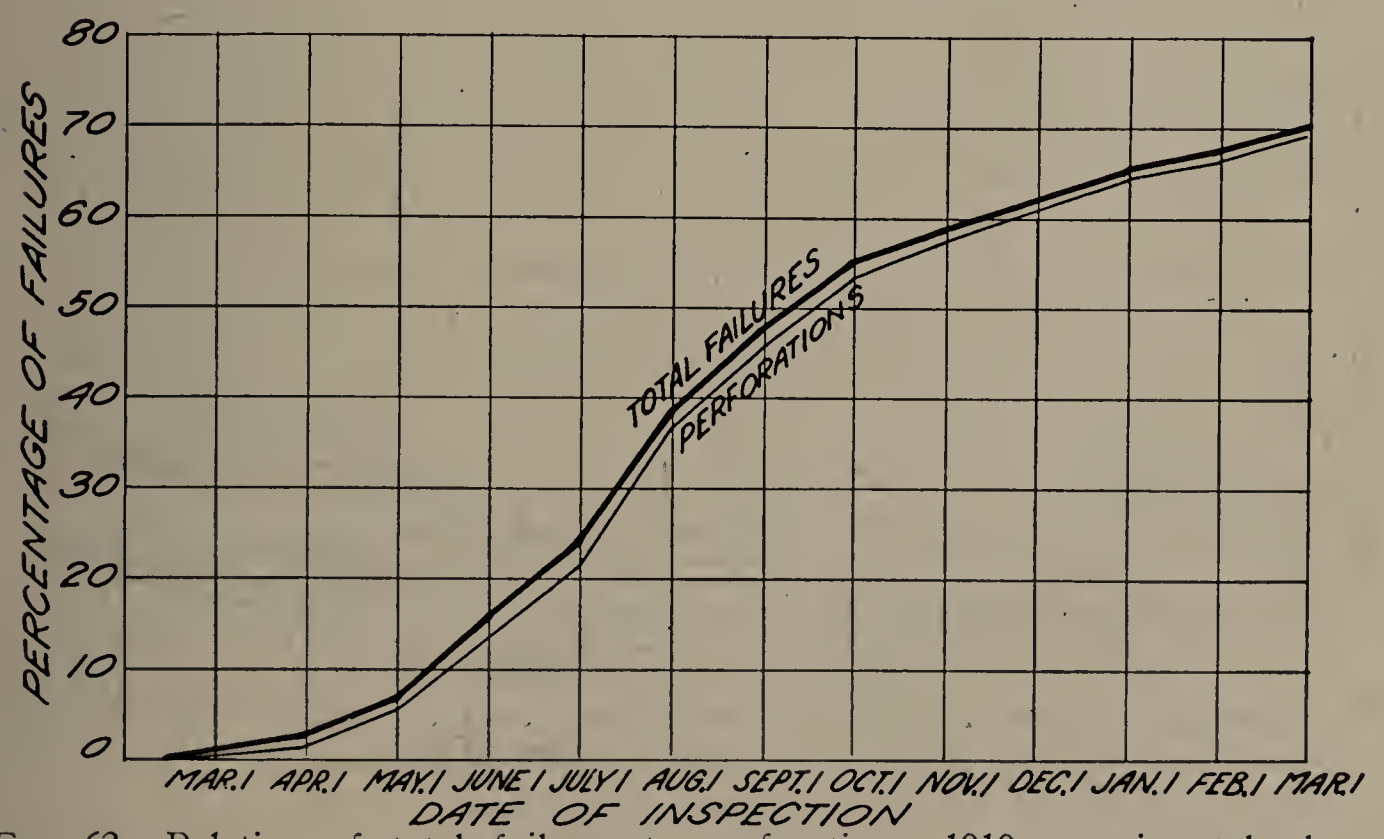


FIG. 62.—Relation of total failures to perforations, 1919 experimental plate; average of all products in all types of plate, enameled cans (Table 104).

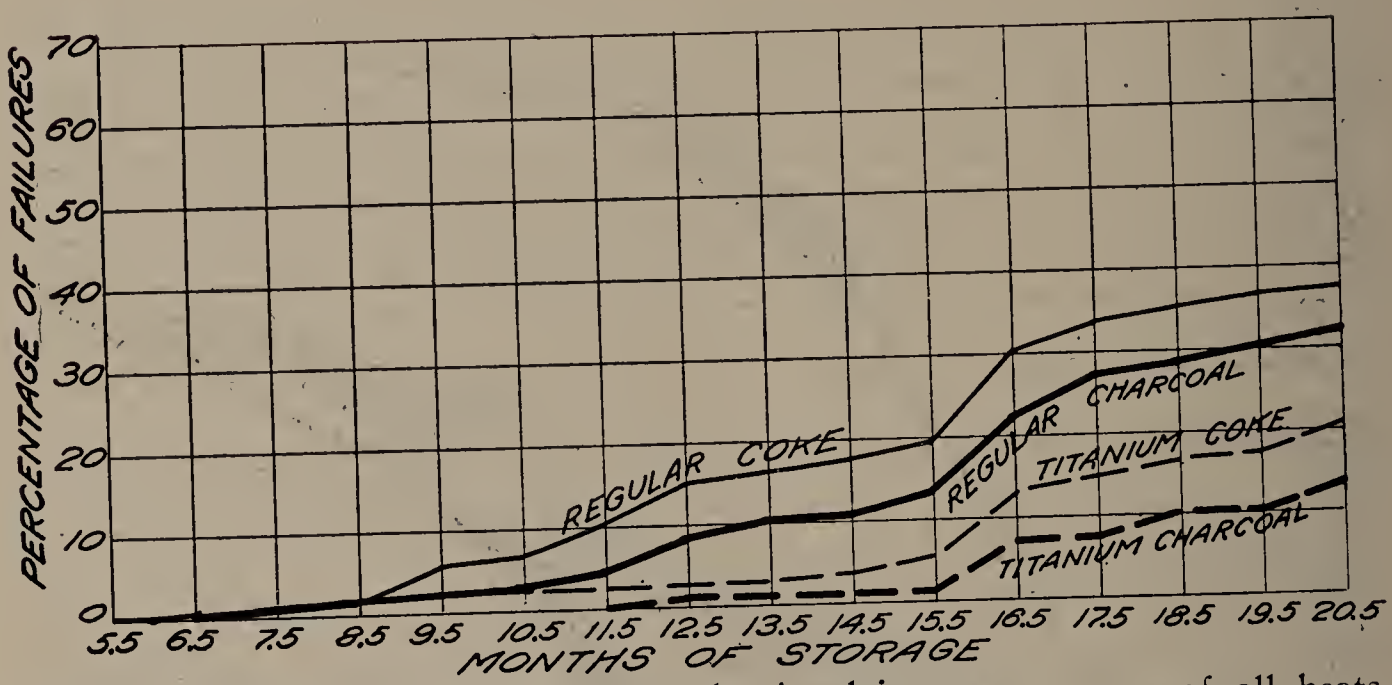


FIG. 63.—Effect of use of titanium; apples in plain cans, average of all heats, 1917 experimental plate (Table 105).

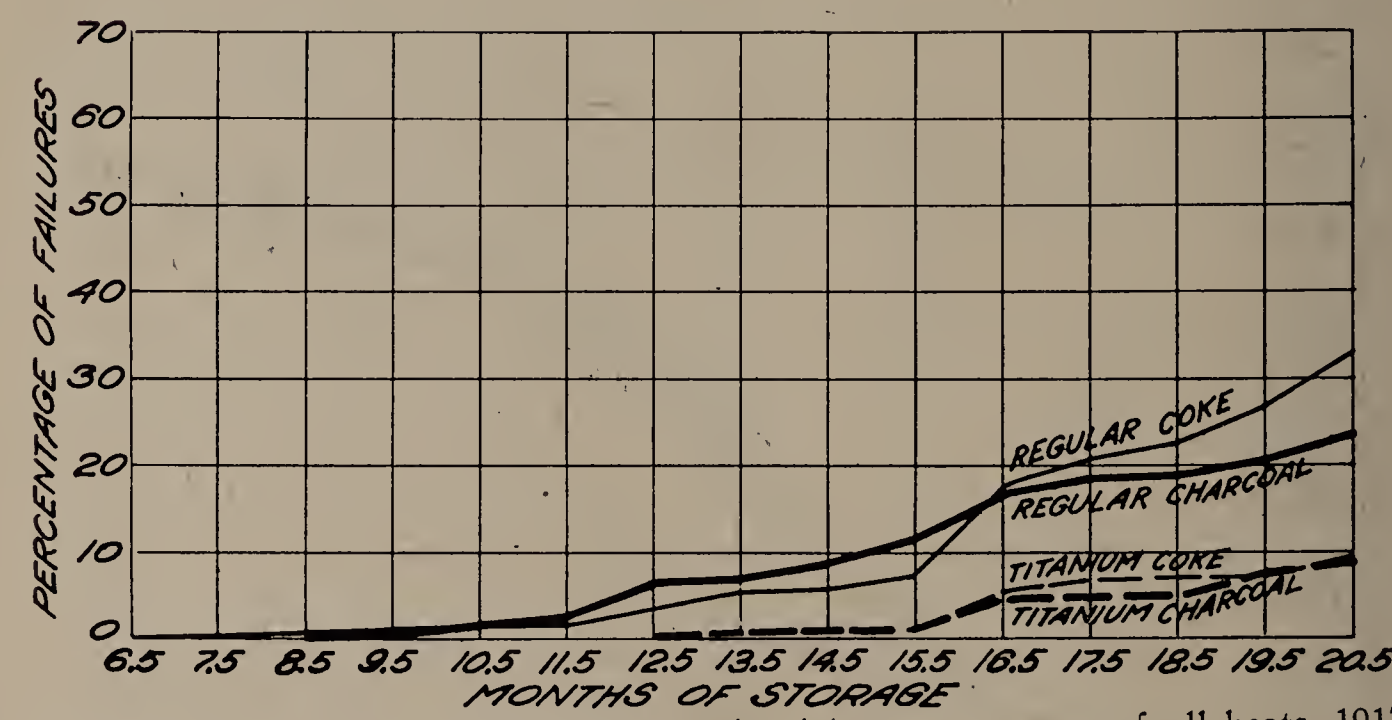


FIG. 64.—Effect of use of titanium; cider in plain cans, average of all heats, 1917 experimental plate (Table 105).

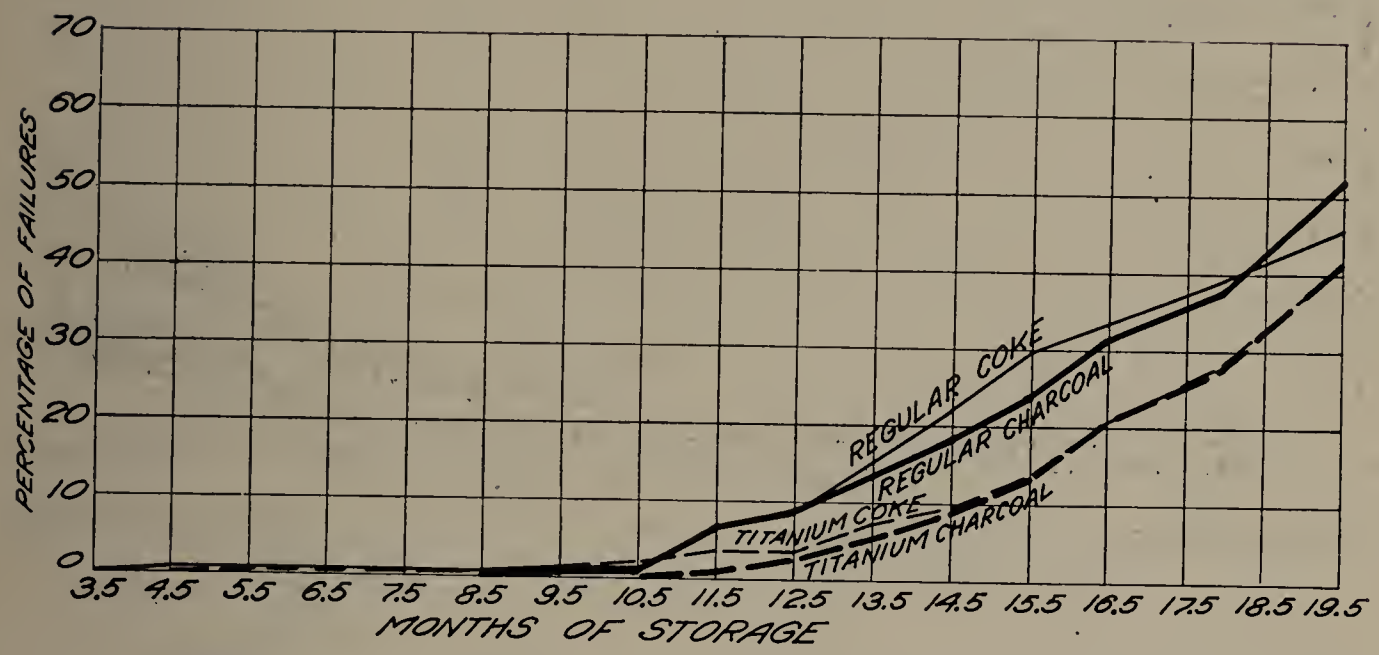


FIG. 65.—Effect of use of titanium; blueberries in plain cans, average of all heats, 1917 experimental plate (Table 106).

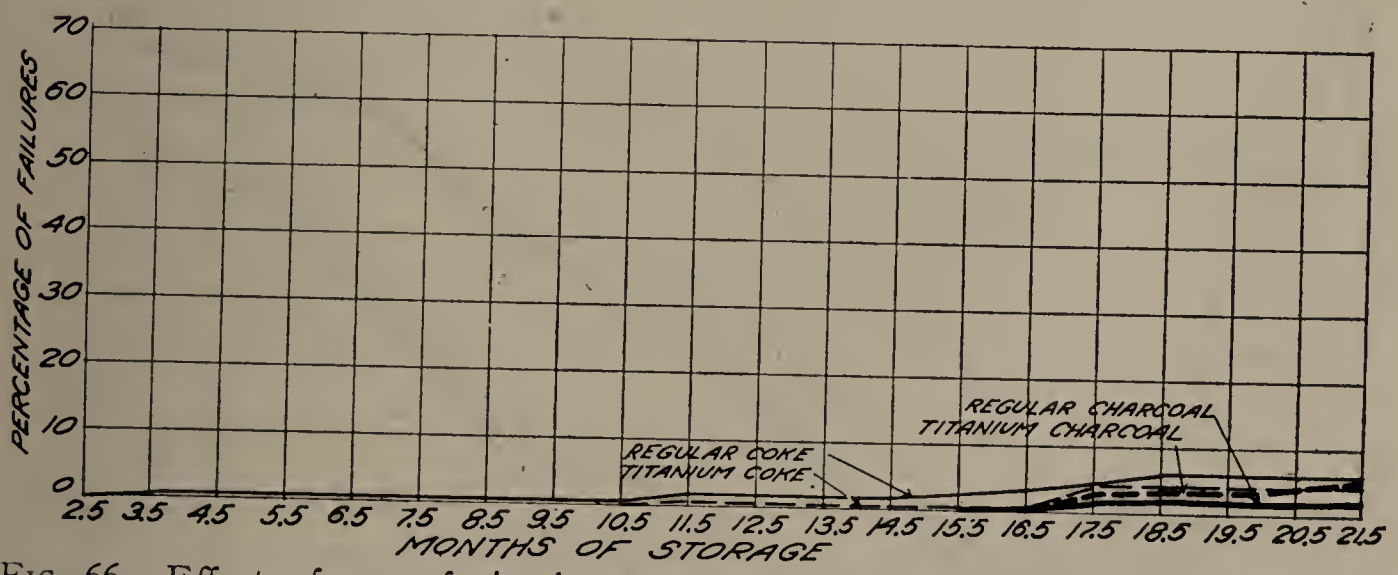


FIG. 66.—Effect of use of titanium; strawberries in plain cans, average of all heats, 1917 experimental plate (Table 107).

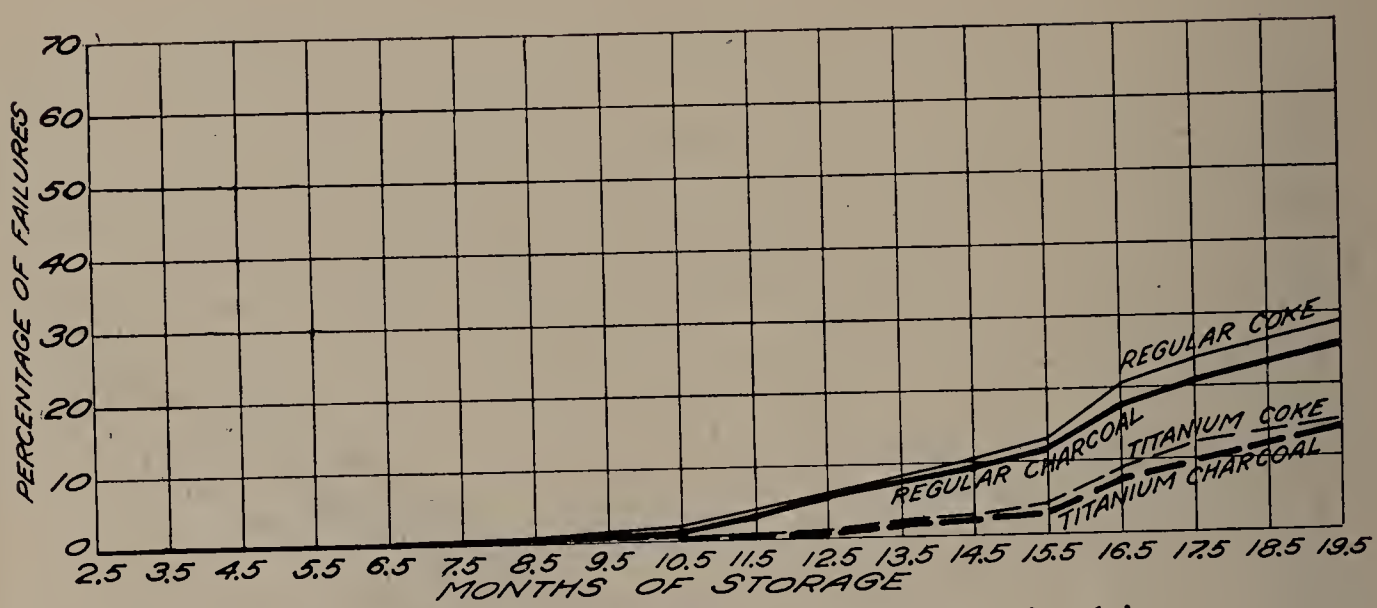


FIG. 67.—Effect of use of titanium; average of all products in plain cans, average of all heats, 1917 experimental plate (Table 108).

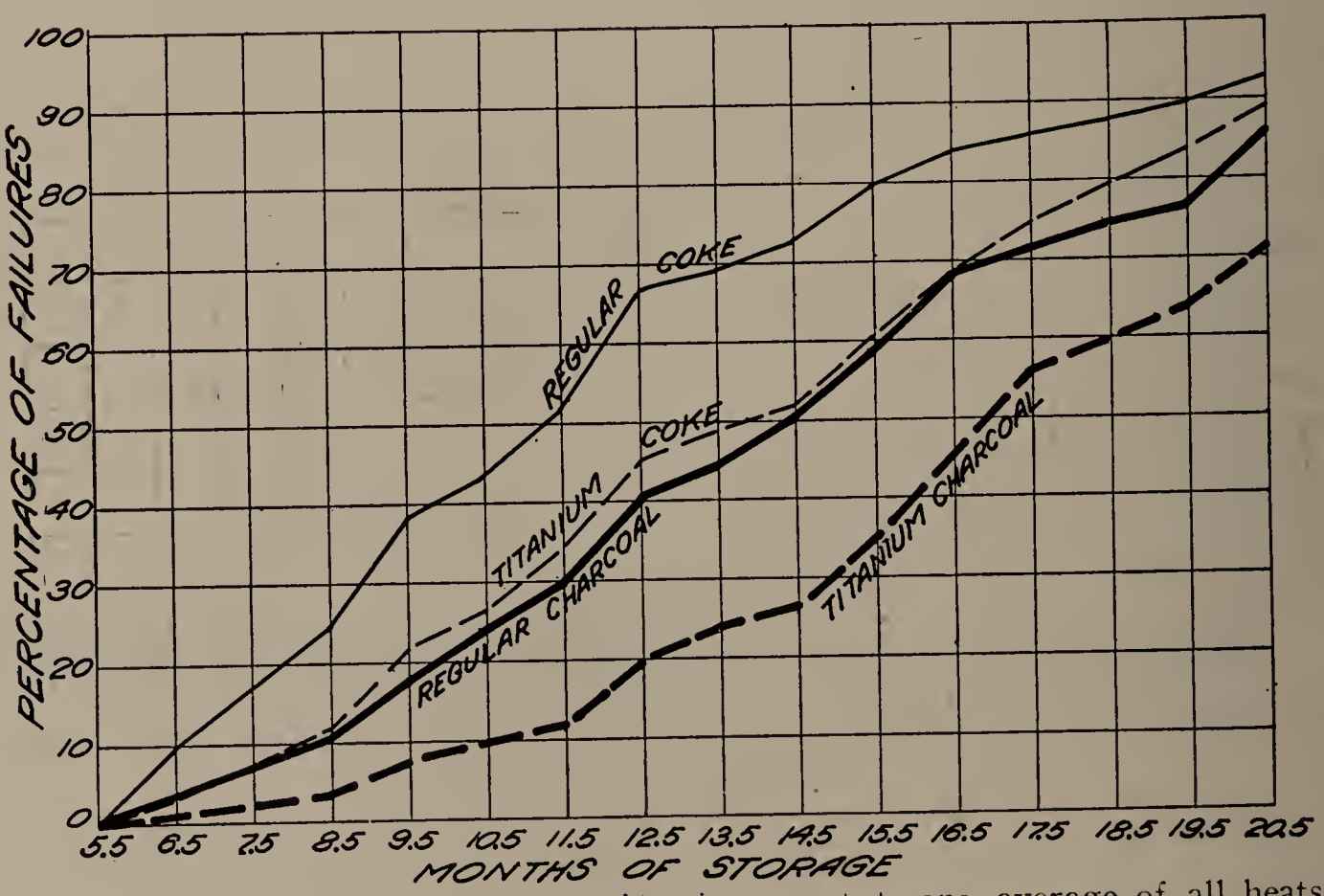


FIG. 68.—Effect of use of titanium; cider in enameled cans, average of all heats, 1917 experimental plate (Table 105).

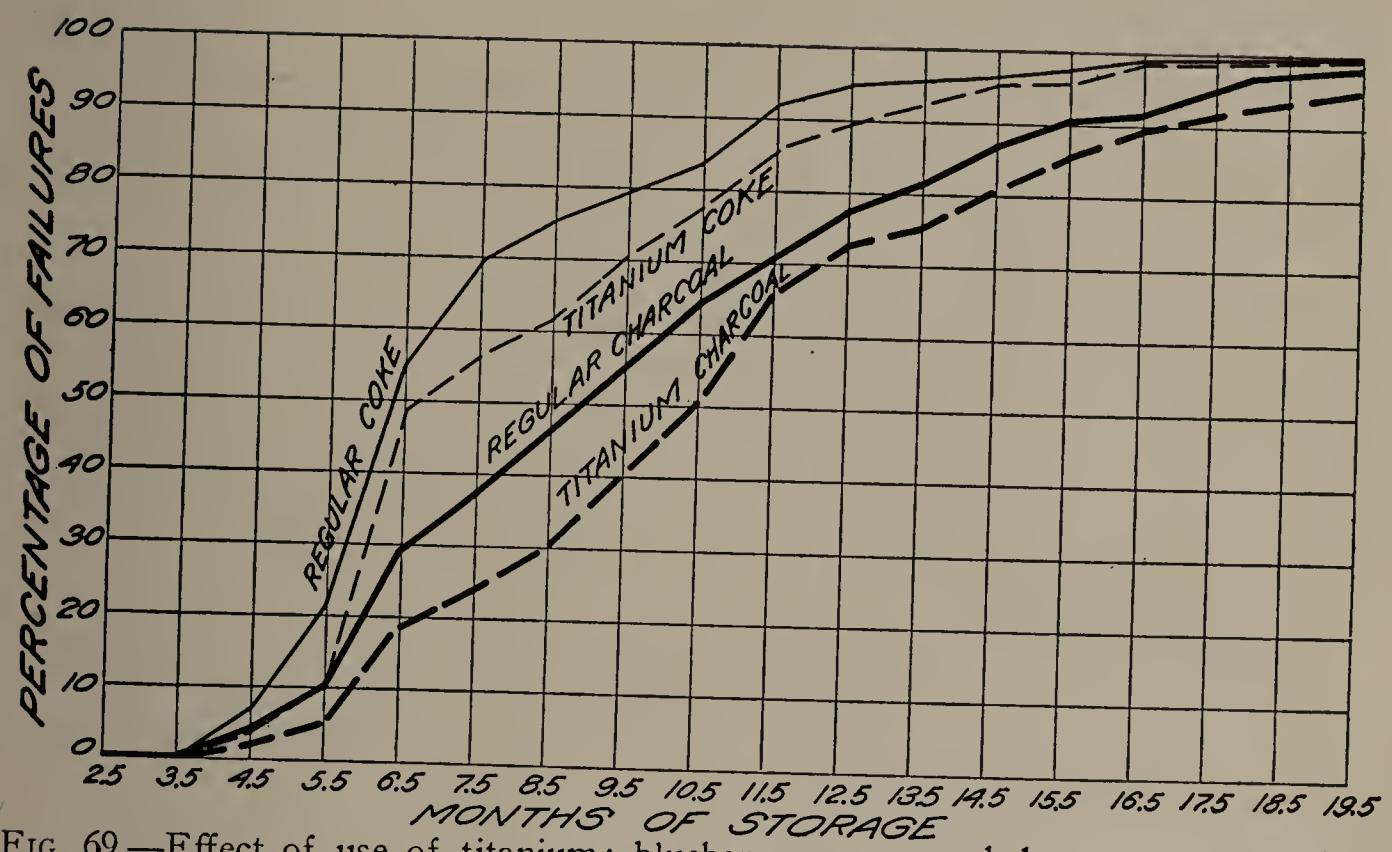


FIG. 69.—Effect of use of titanium: blueberries in enameled cans, average of all heats, 1917 experimental plate (Table 106).

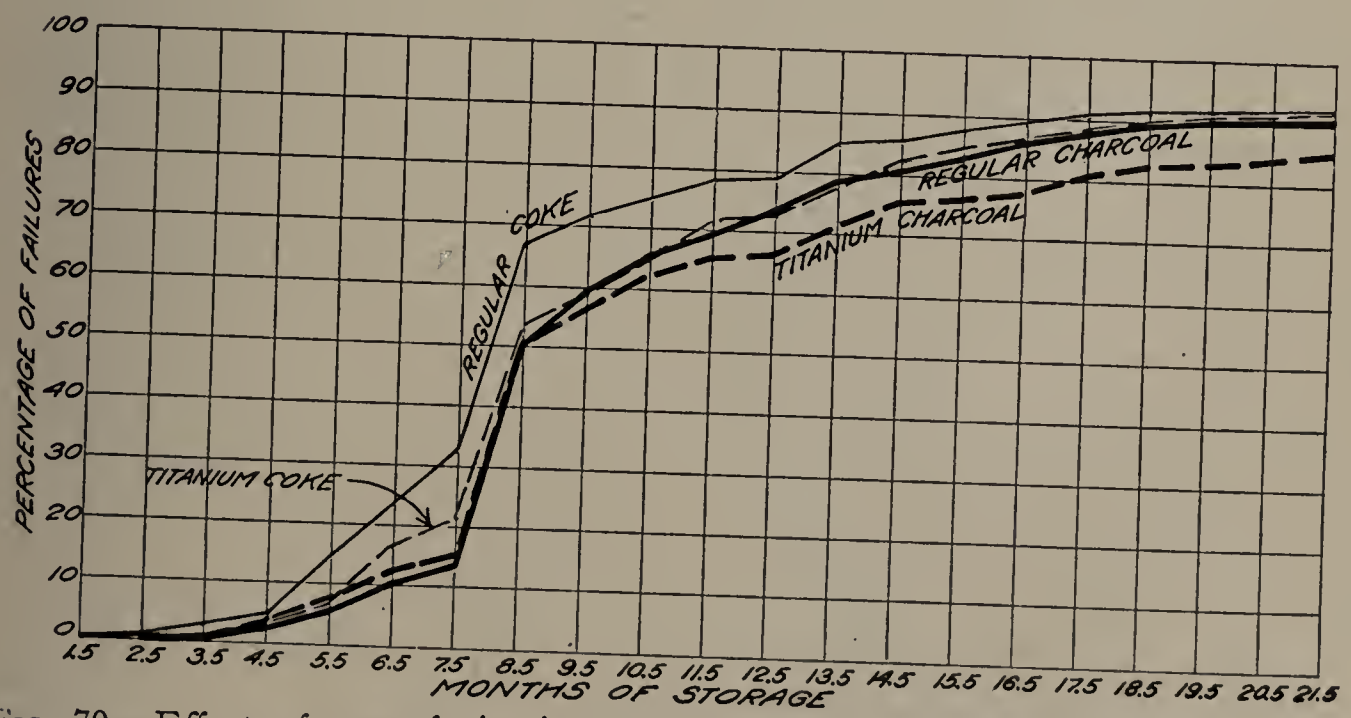


FIG. 70.—Effect of use of titanium; strawberries in enameled cans, average of all heats, 1917 experimental plate (Table 107).

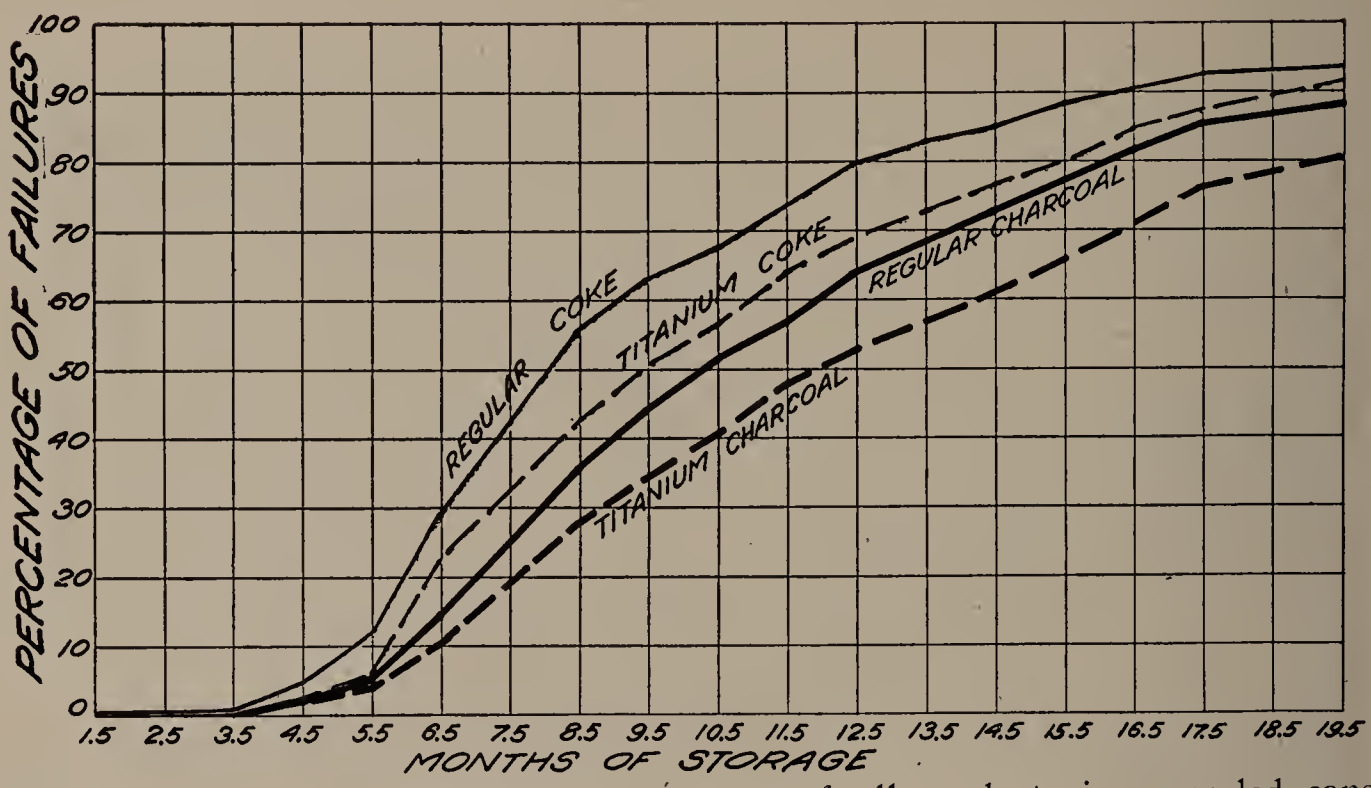


FIG. 71.—Effect of use of titanium; average of all products in enameled cans, average of all heats, 1917 experimental plate (Table 108).

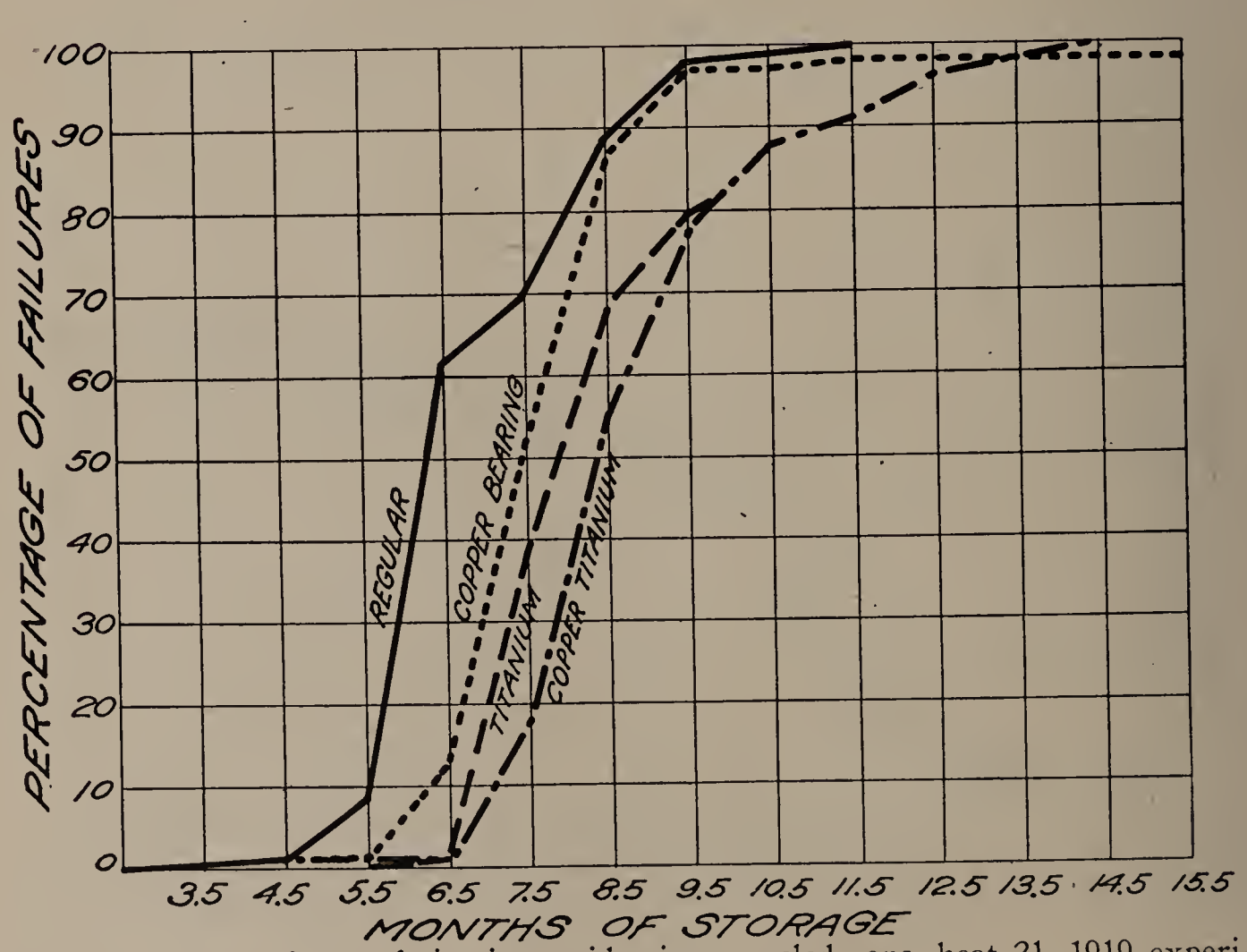


FIG. 72.—Effect of use of titanium; cider in enameled cans, heat 21, 1919 experimental plate (Table 109).

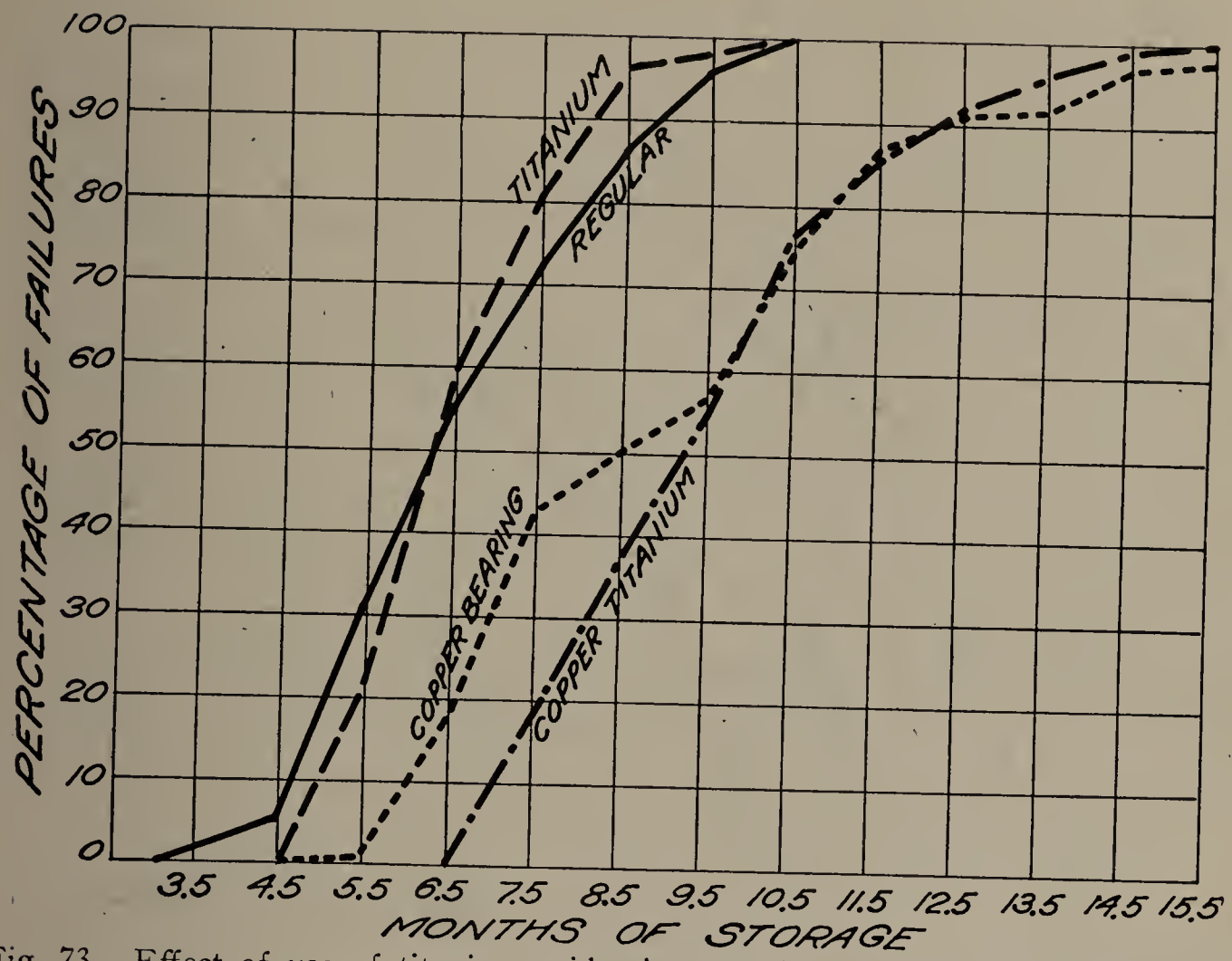


Fig. 73.—Effect of use of titanium; cider in enameled cans, heat 22, 1919 experimental plate (Table 109).

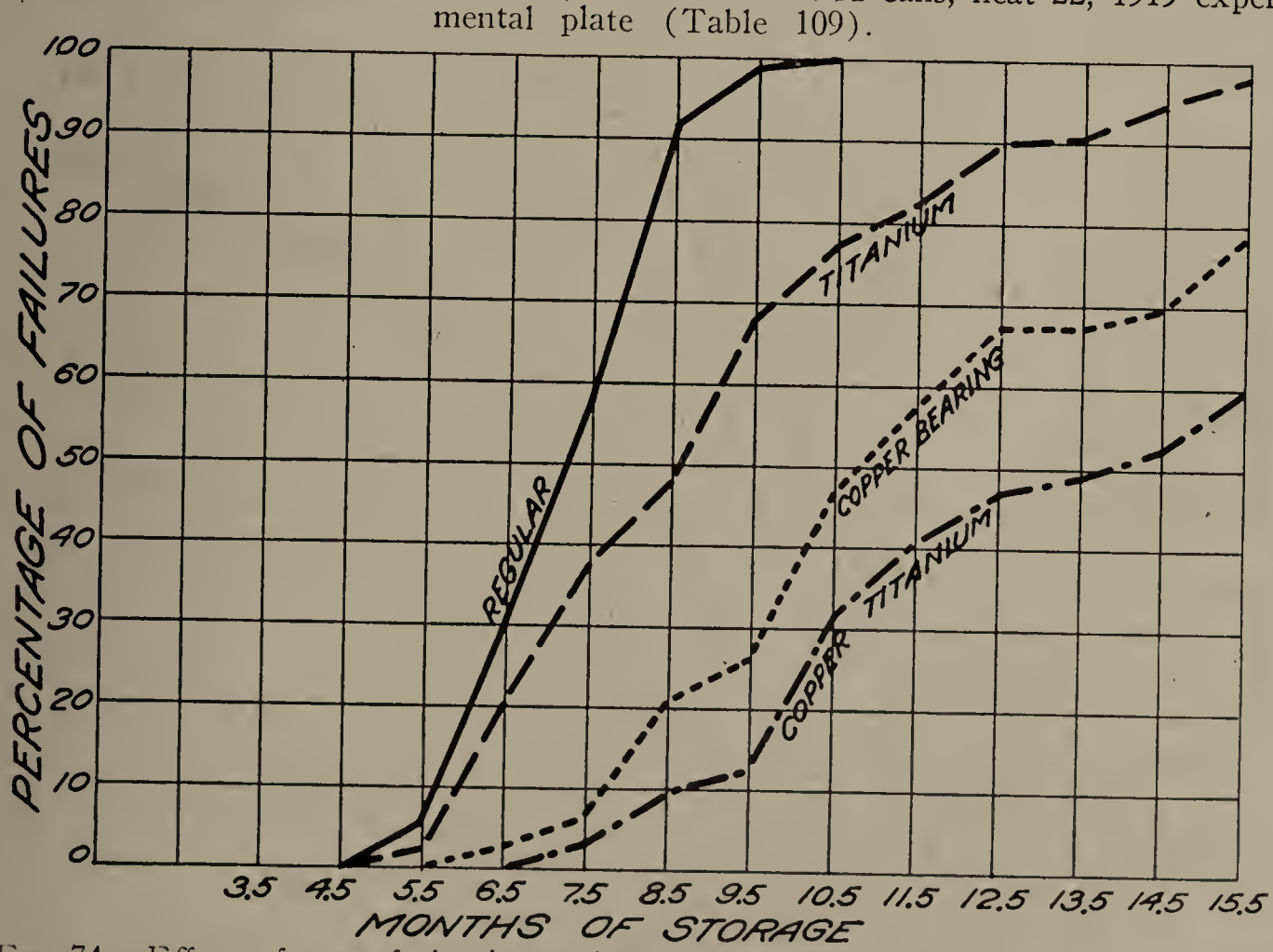


Fig. 74.—Effect of use of titanium; cider in enameled cans, heat 23, 1919 experimental plate (Table 109).

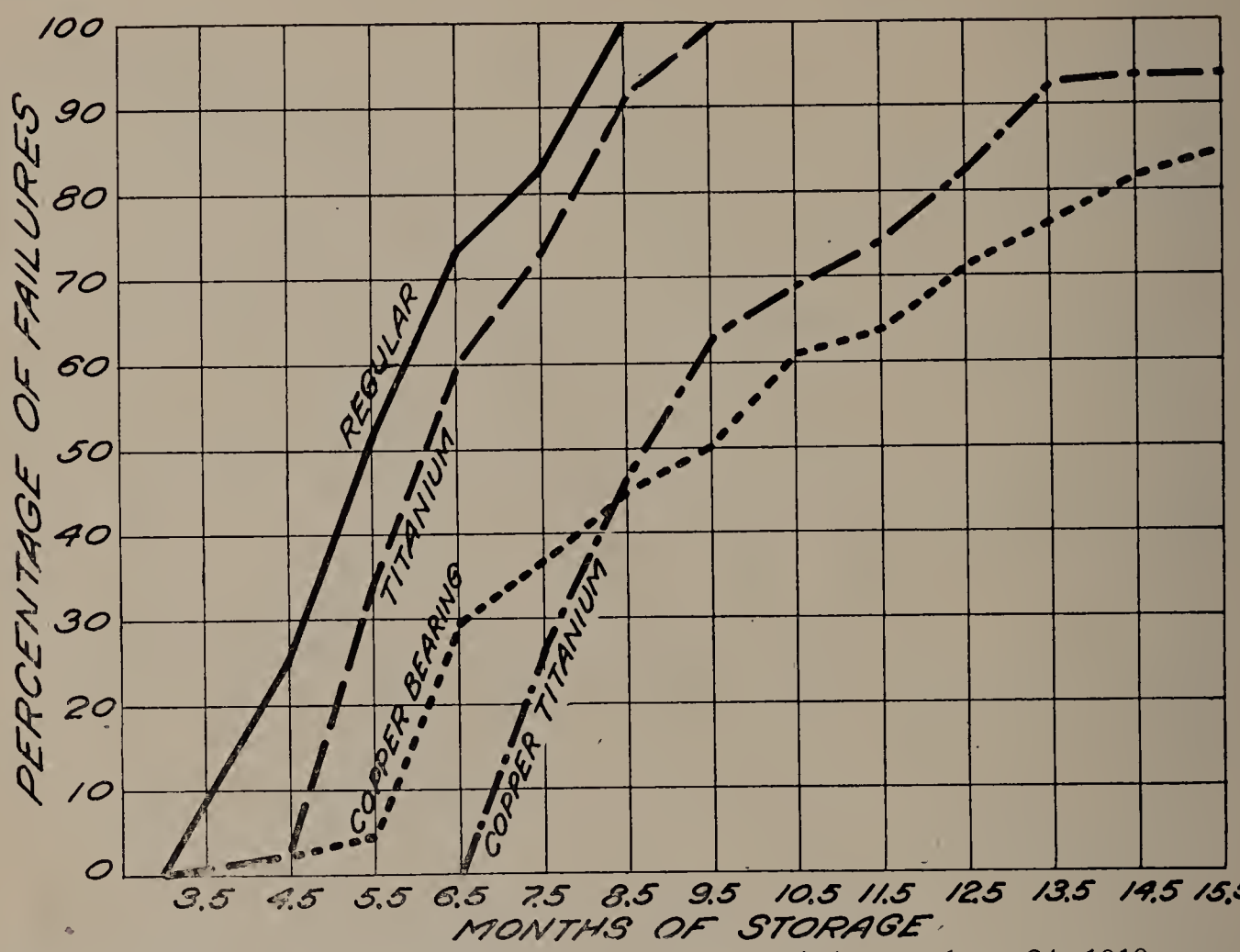


FIG. 75.—Effect of use of titanium; cider in enameled cans, heat 24, 1919 experimental plate (Table 109).

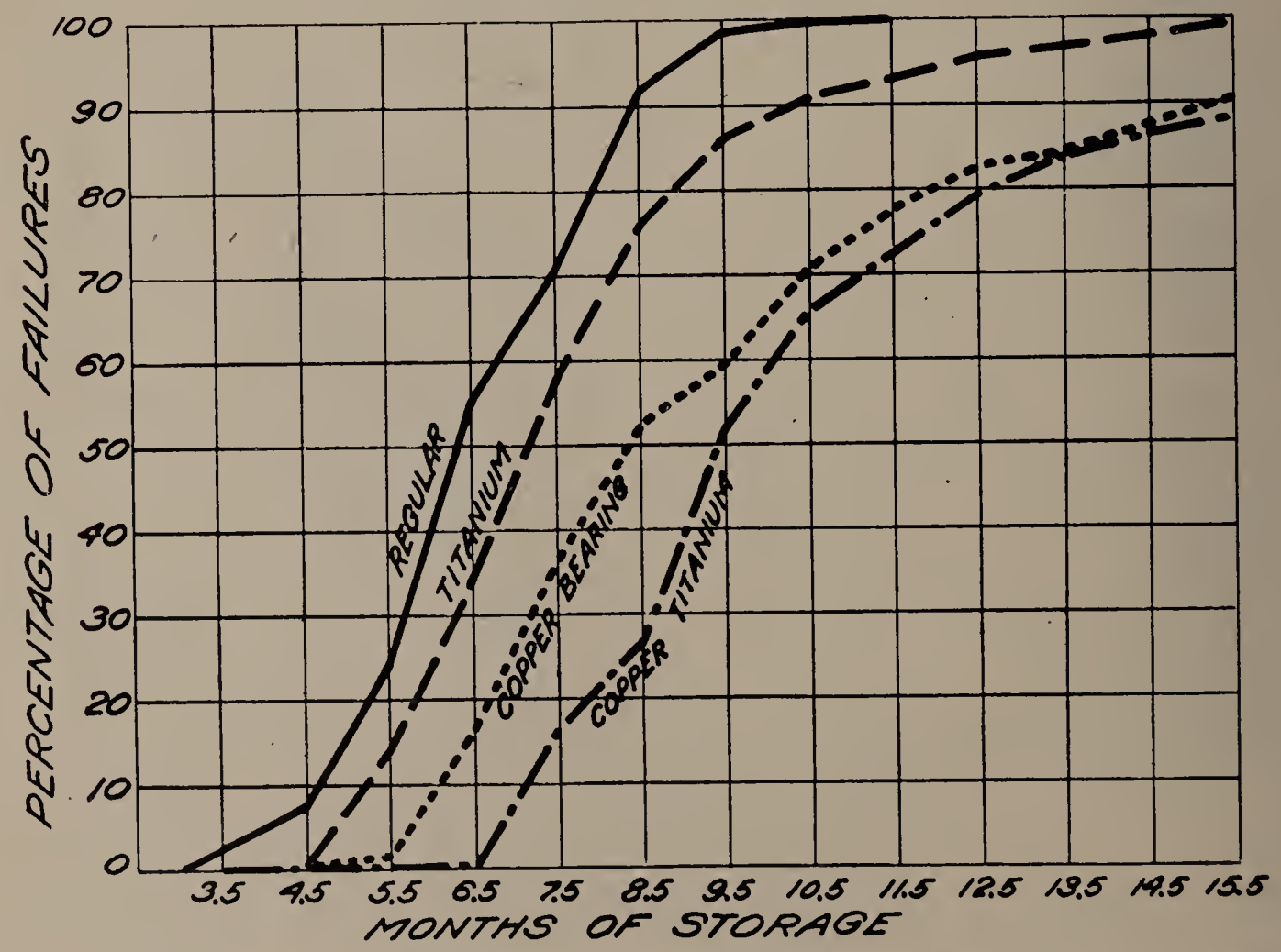


FIG. 76.—Effect of use of titanium; cider in enameled cans, average of all heats, 1919 experimental plate (Table 109).

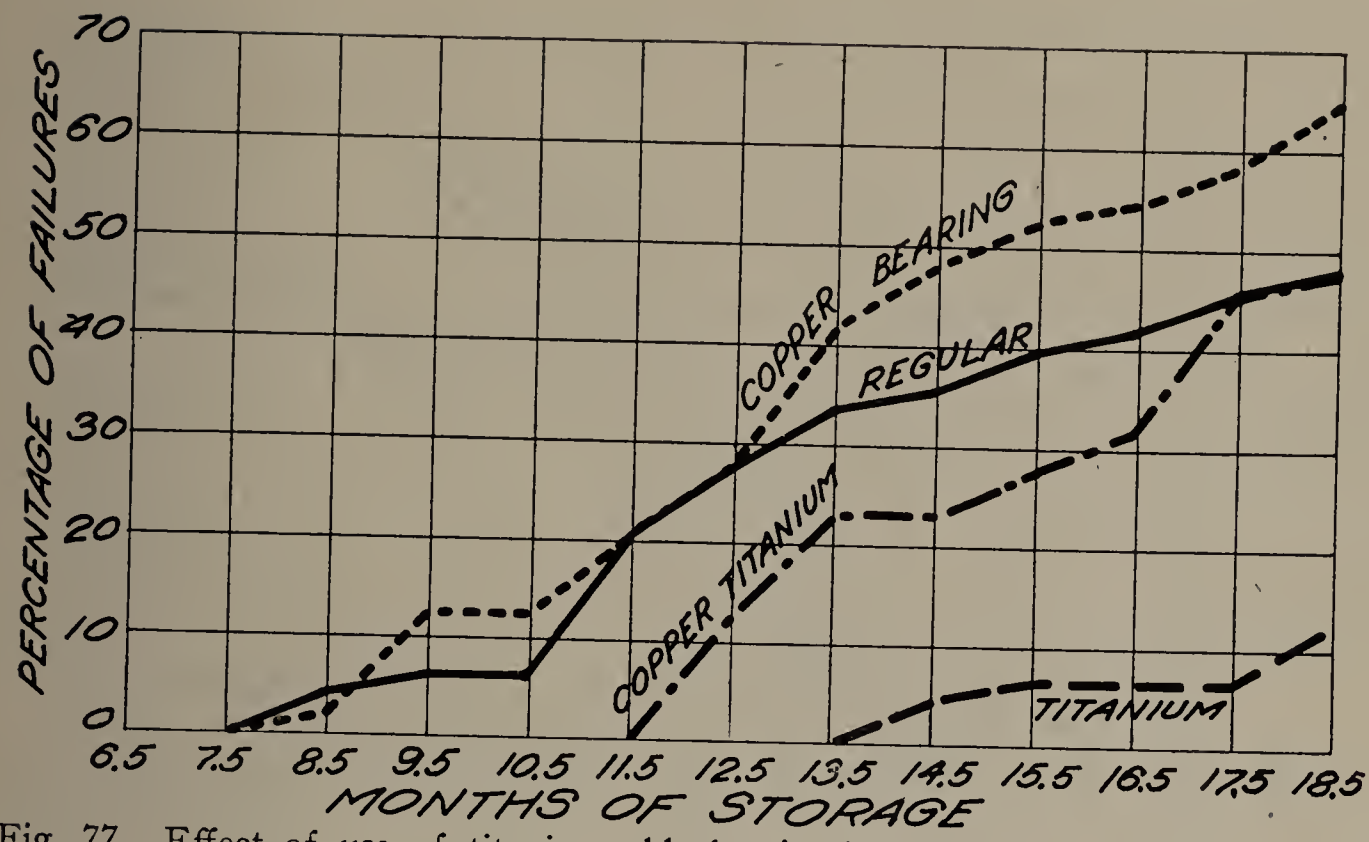


Fig. 77.—Effect of use of titanium; blueberries in enameled cans, heat 21, 1919 experimental plate (Table 110).

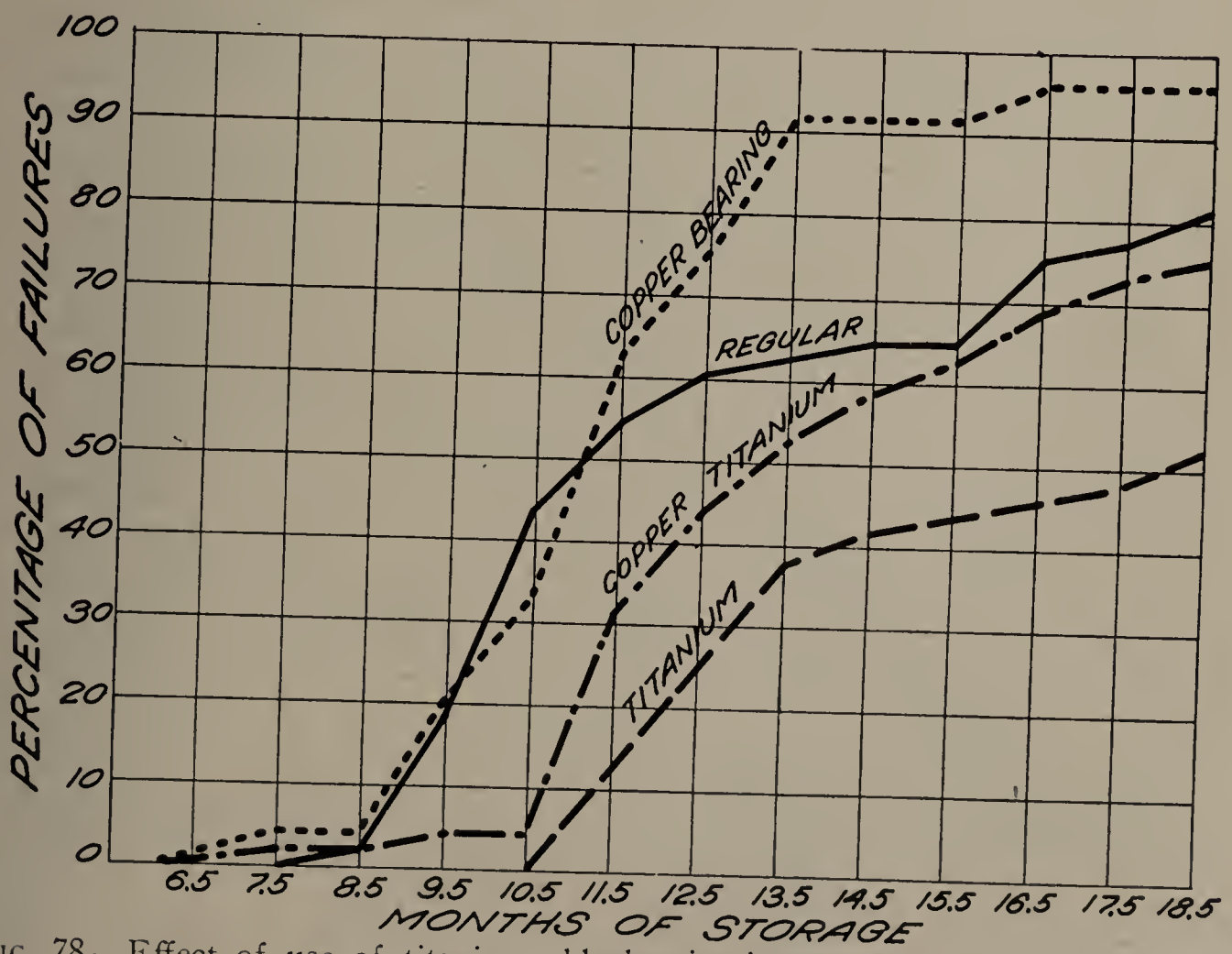


Fig. 78.—Effect of use of titanium; blueberries in enameled cans, heat 22, 1919 experimental plate (Table 110).

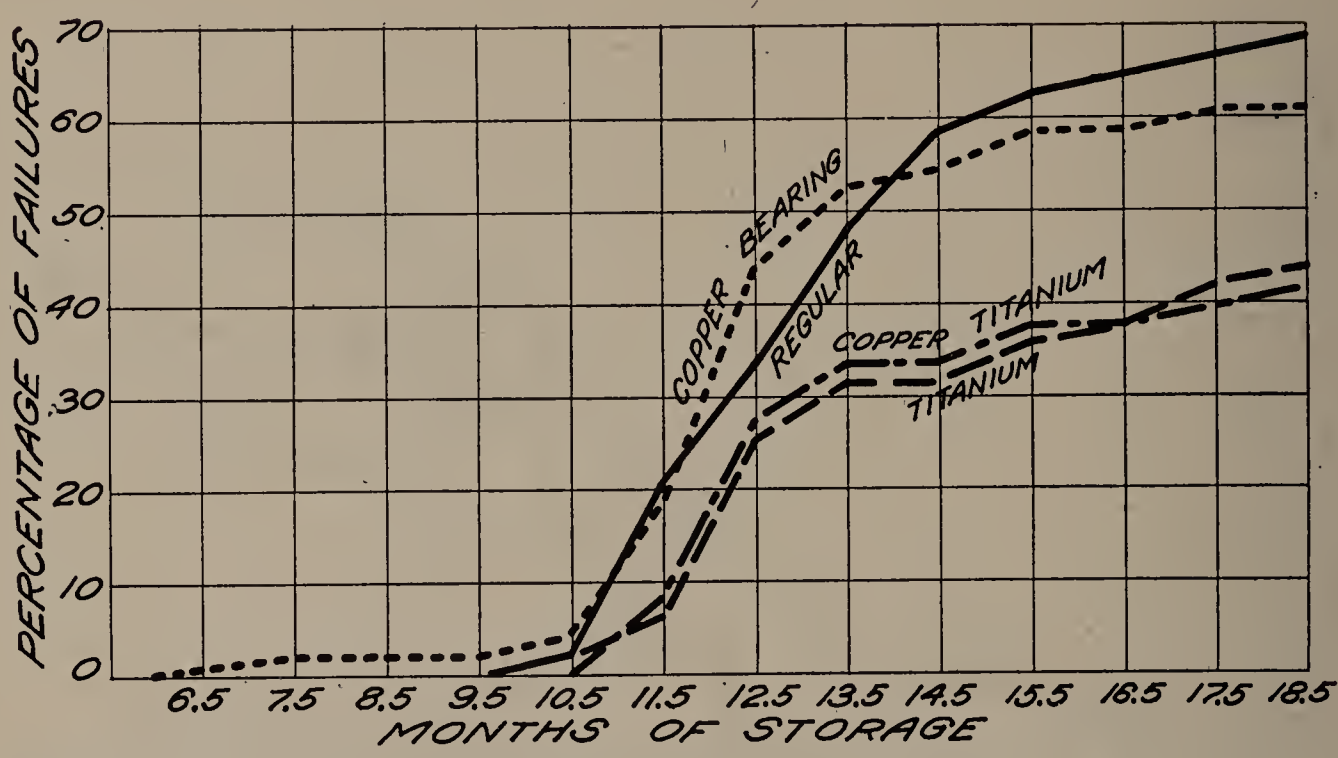


FIG. 79.—Effect of use of titanium; blueberries in enameled cans, heat 23, 1919 experimental plate (Table 110).

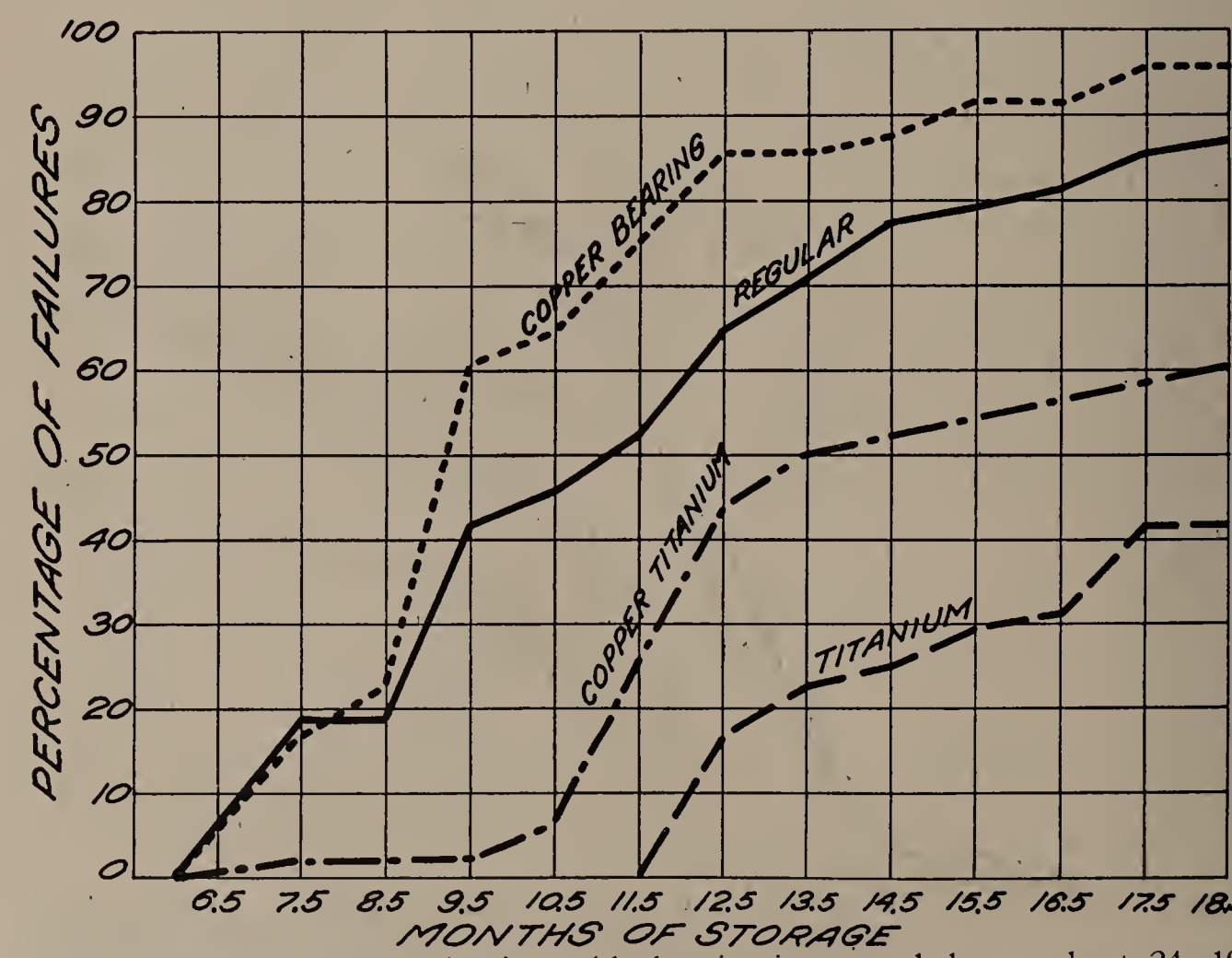


FIG. 80.—Effect of use of titanium; blueberries in enameled cans, heat 24, 1919 experimental plate (Table 110).

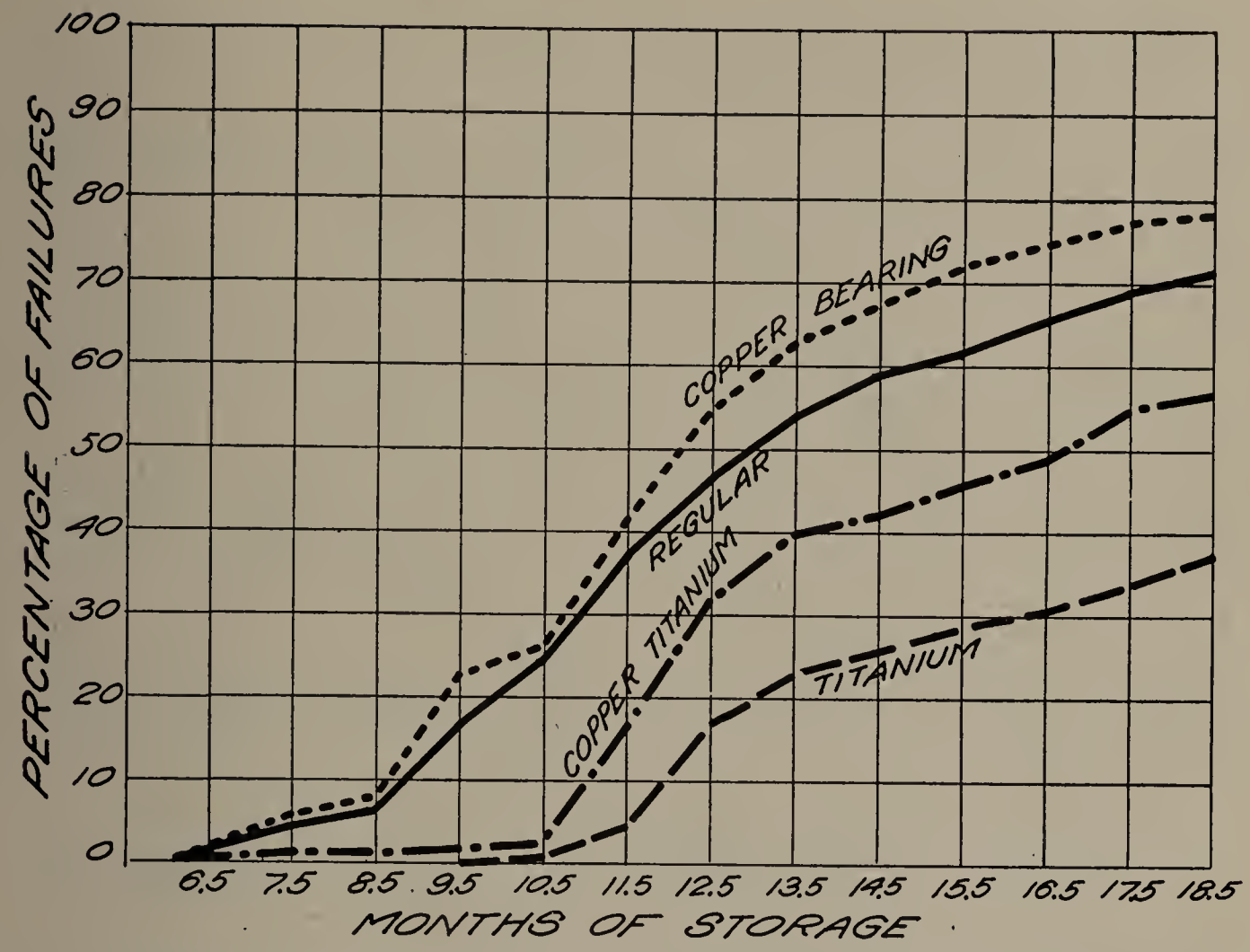


FIG. 81.—Effect of use of titanium; blueberries in enameled cans, average of all heats, 1919 experimental plate (Table 110).

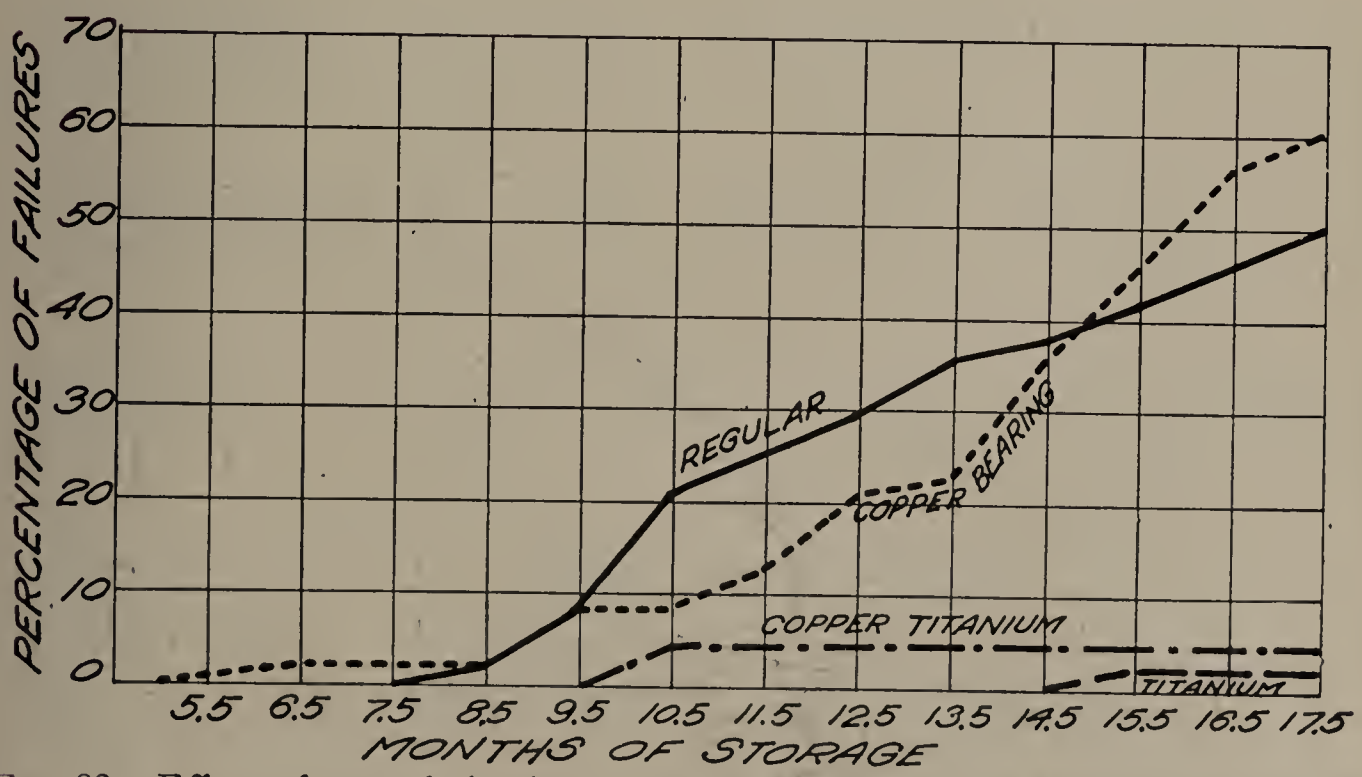


FIG. 82.—Effect of use of titanium; peaches in enameled cans, heat 21, 1919 experimental plate (Table 111).

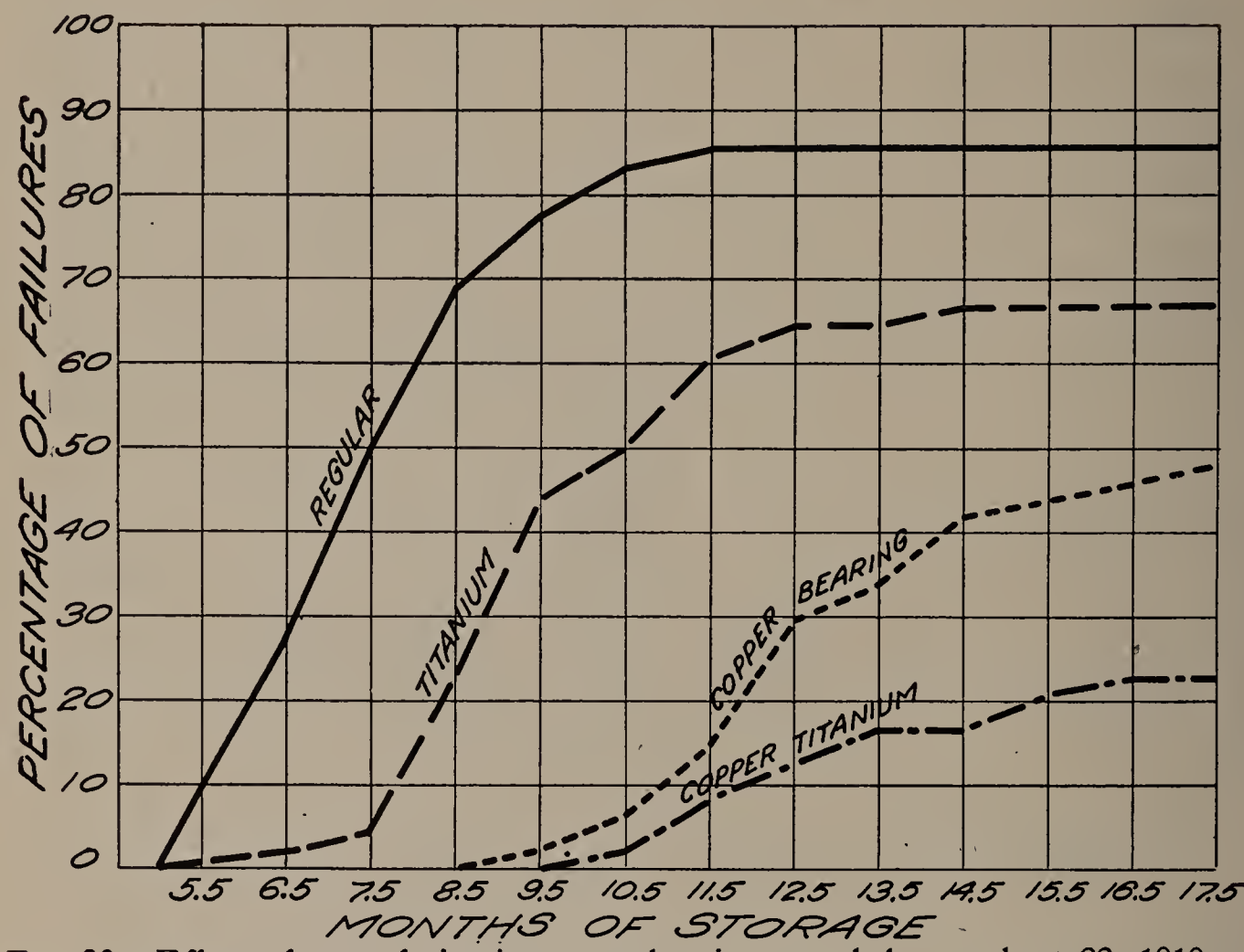


FIG. 83.—Effect of use of titanium; peaches in enameled cans, heat 22, 1919 experimental plate (Table 111).

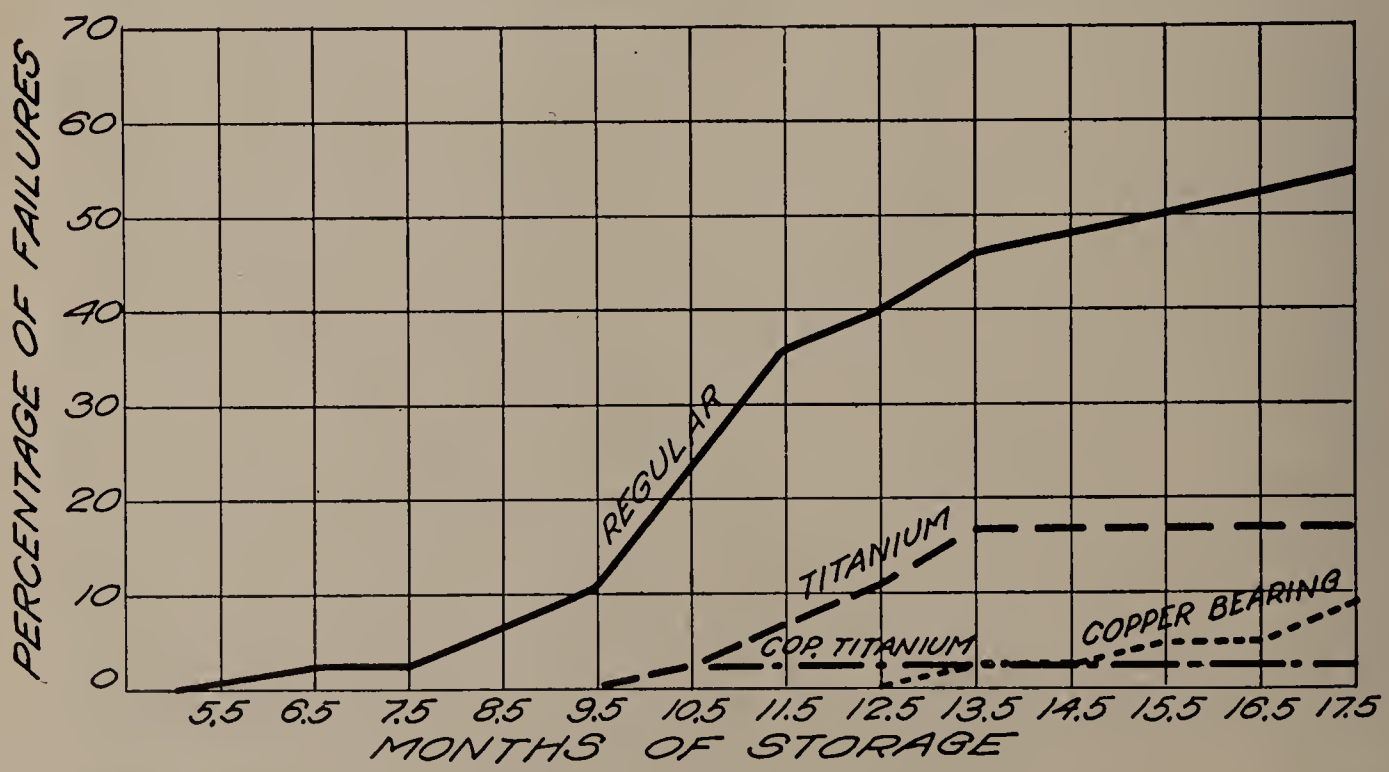


FIG. 84.—Effect of use of titanium; peaches in enameled cans, heat 23, 1919 experimental plate (Table 111).

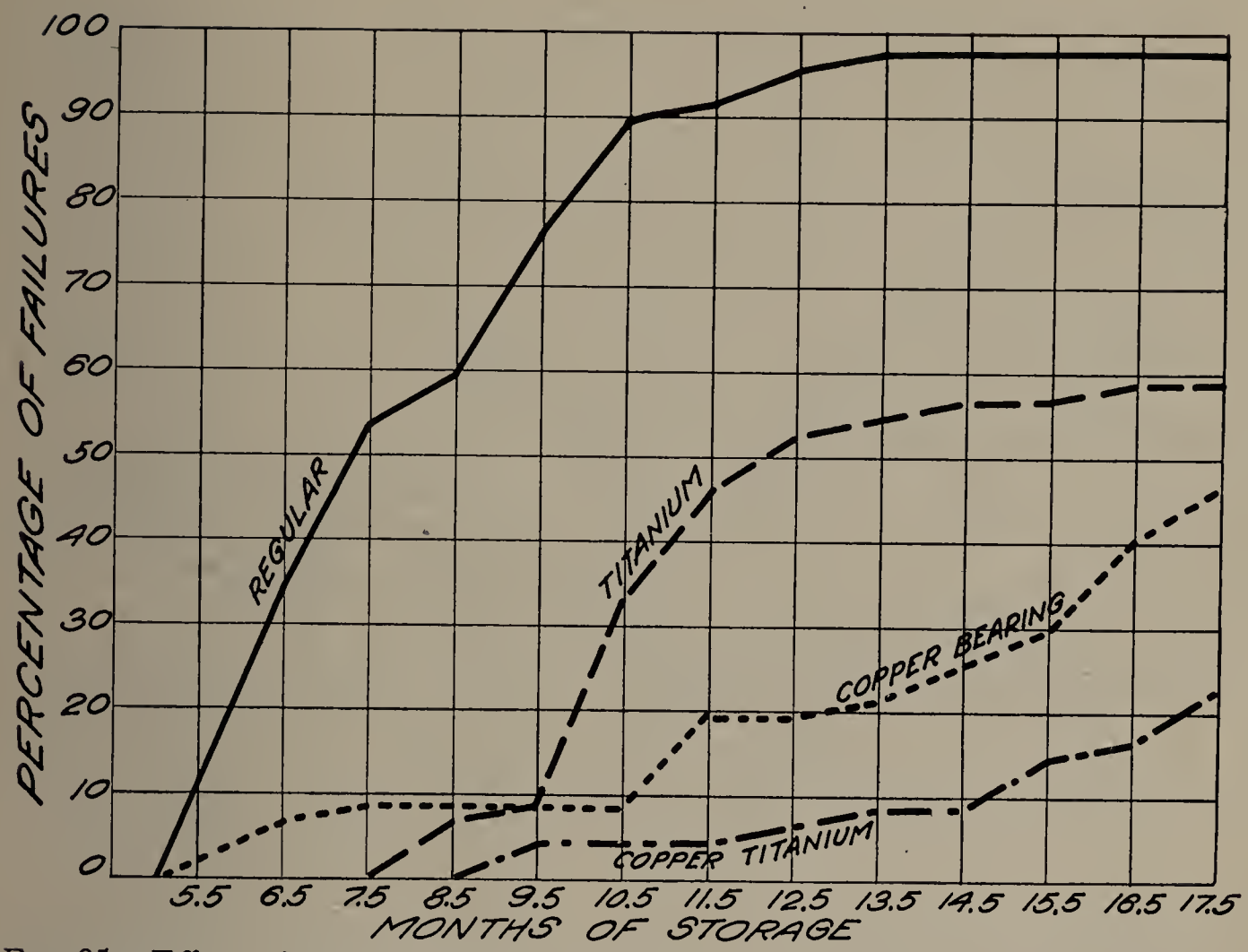


FIG. 85.—Effect of use of titanium; peaches in enameled cans, heat 24, 1919 experimental plate (Table 111).

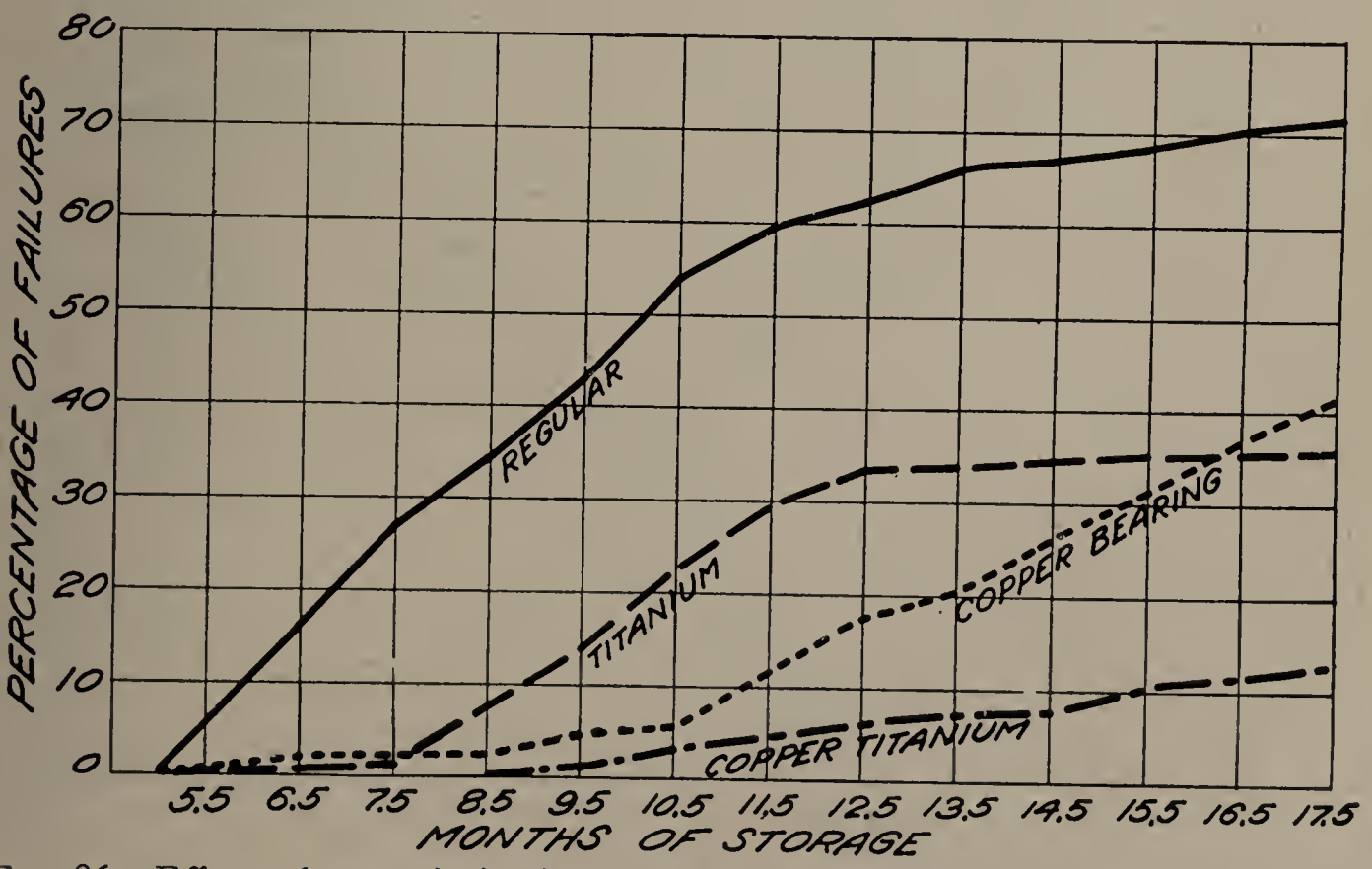


FIG. 86.—Effect of use of titanium; peaches in enameled cans, average of all heats, 1919 experimental plate (Table 111).

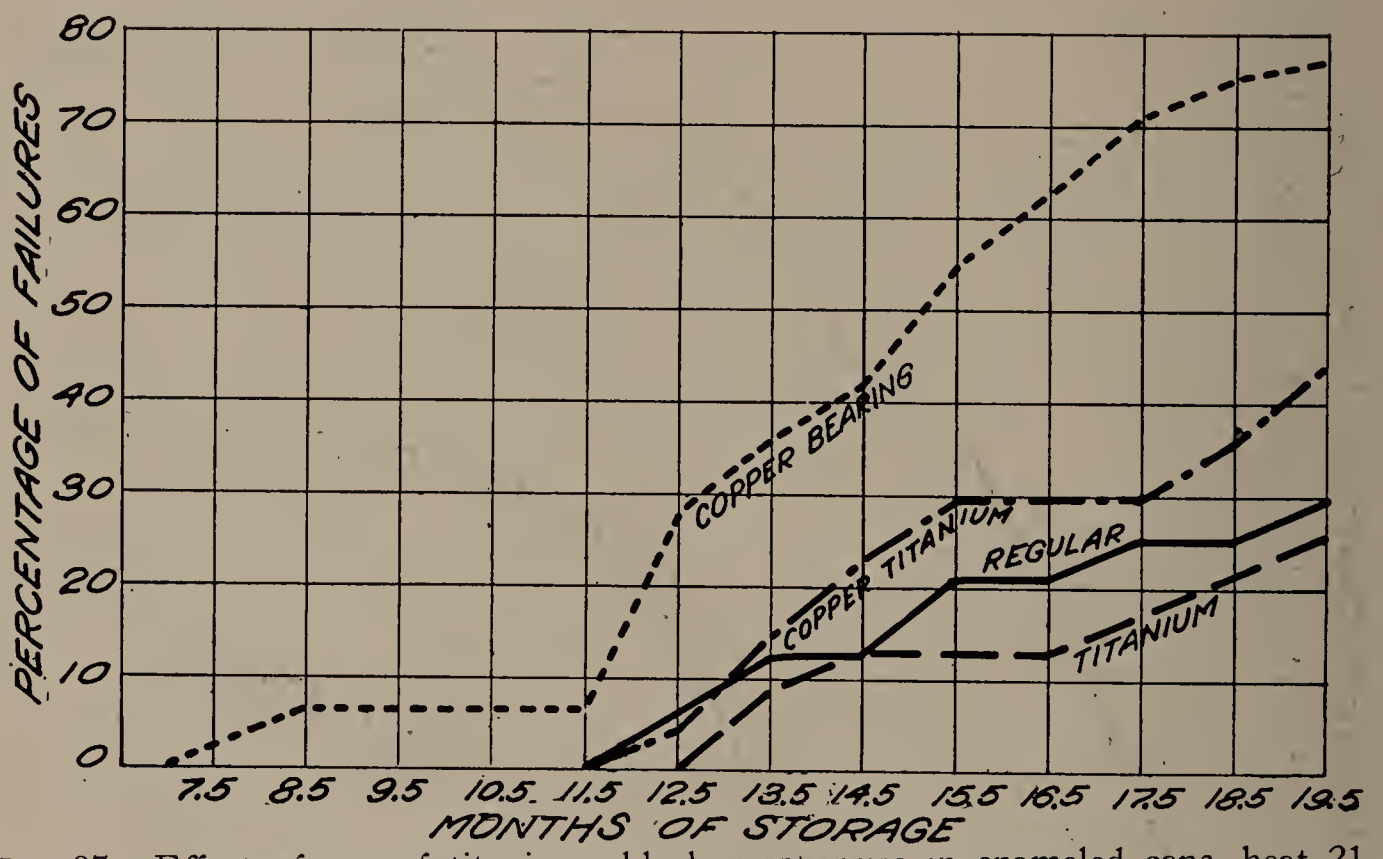


FIG. 87.—Effect of use of titanium; black raspberries in enameled cans, heat 21, 1919 experimental plate (Table 112).

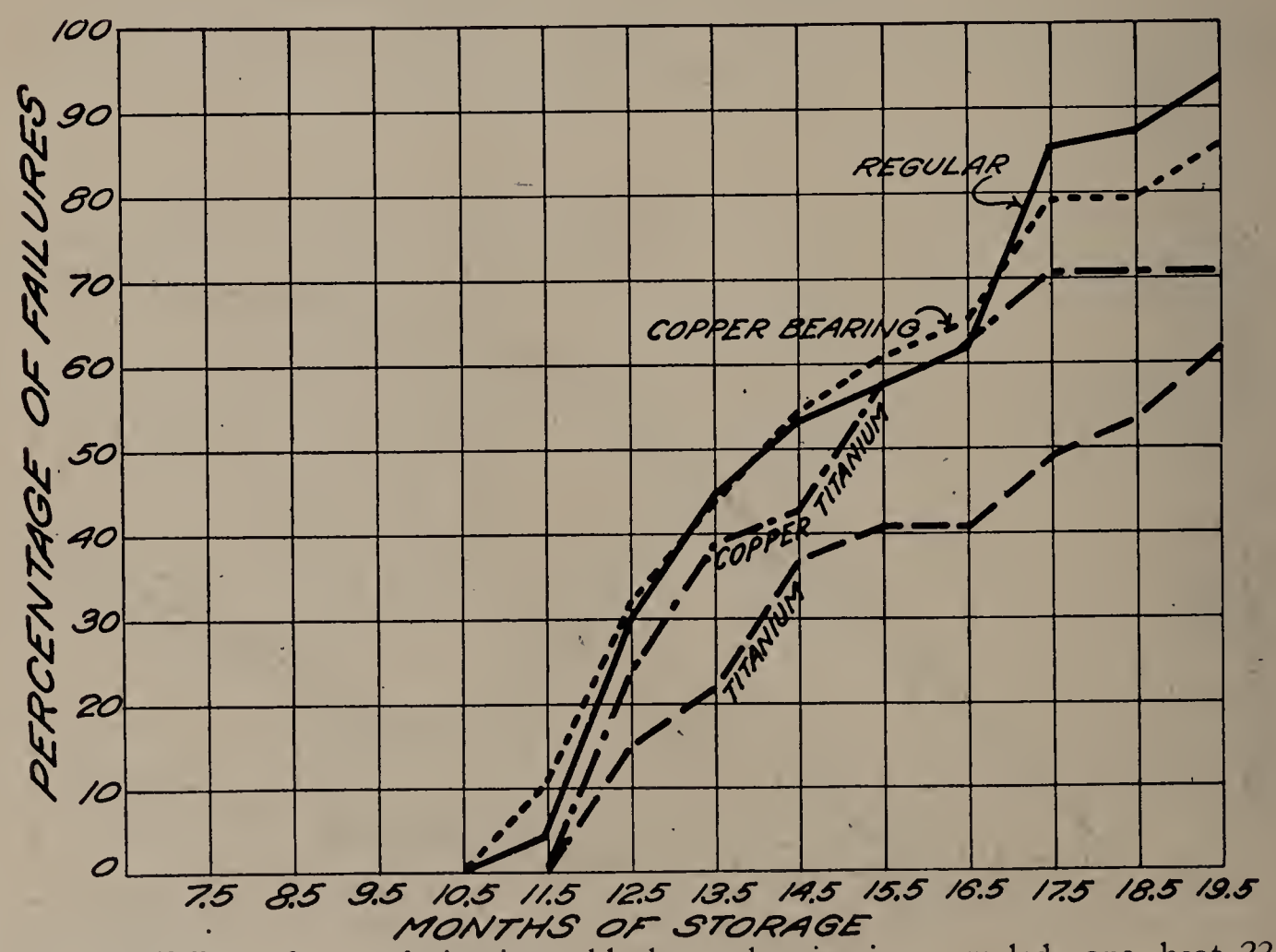


FIG. 88.—Effect of use of titanium; black raspberries in enameled cans, heat 22, 1919 experimental plate (Table 112).

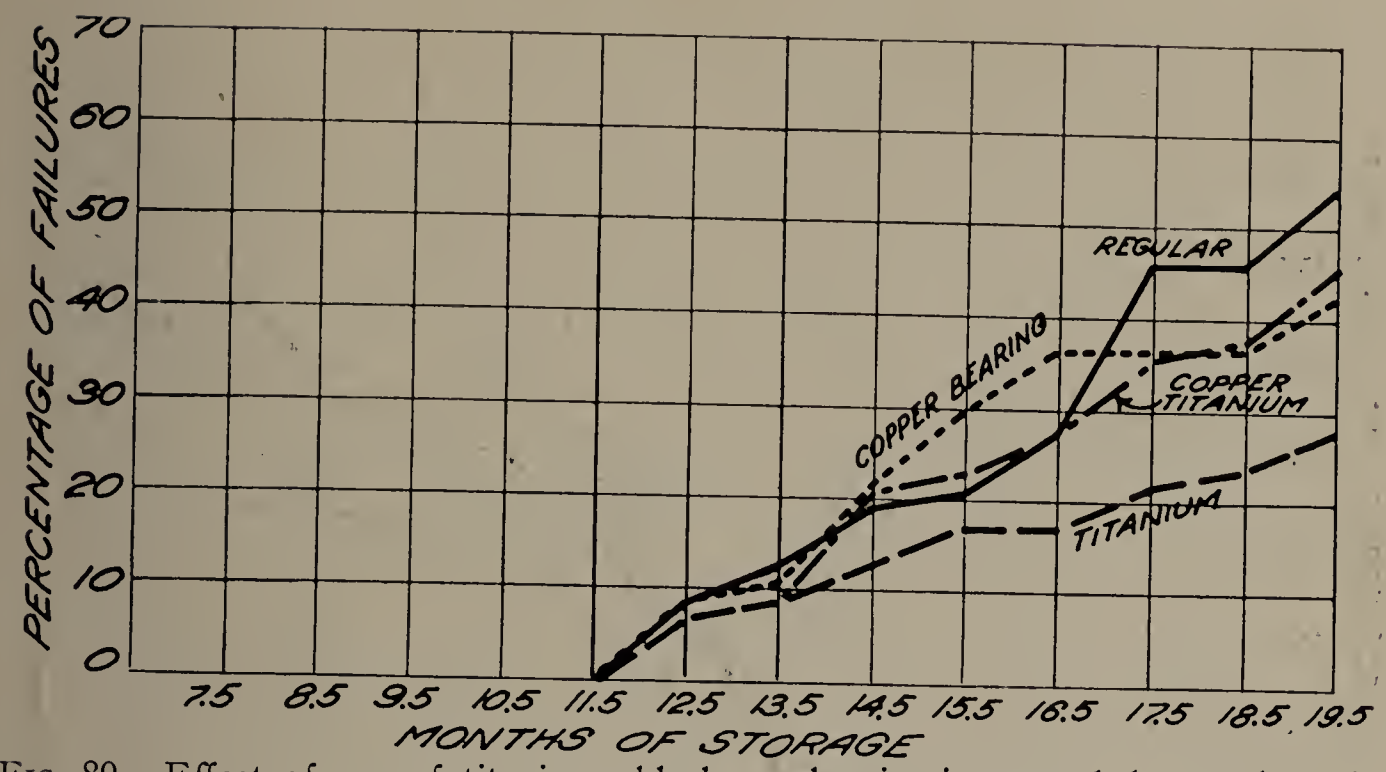


FIG. 89.—Effect of use of titanium; black raspberries in enameled cans, heat 23, 1919 experimental plate (Table 112).

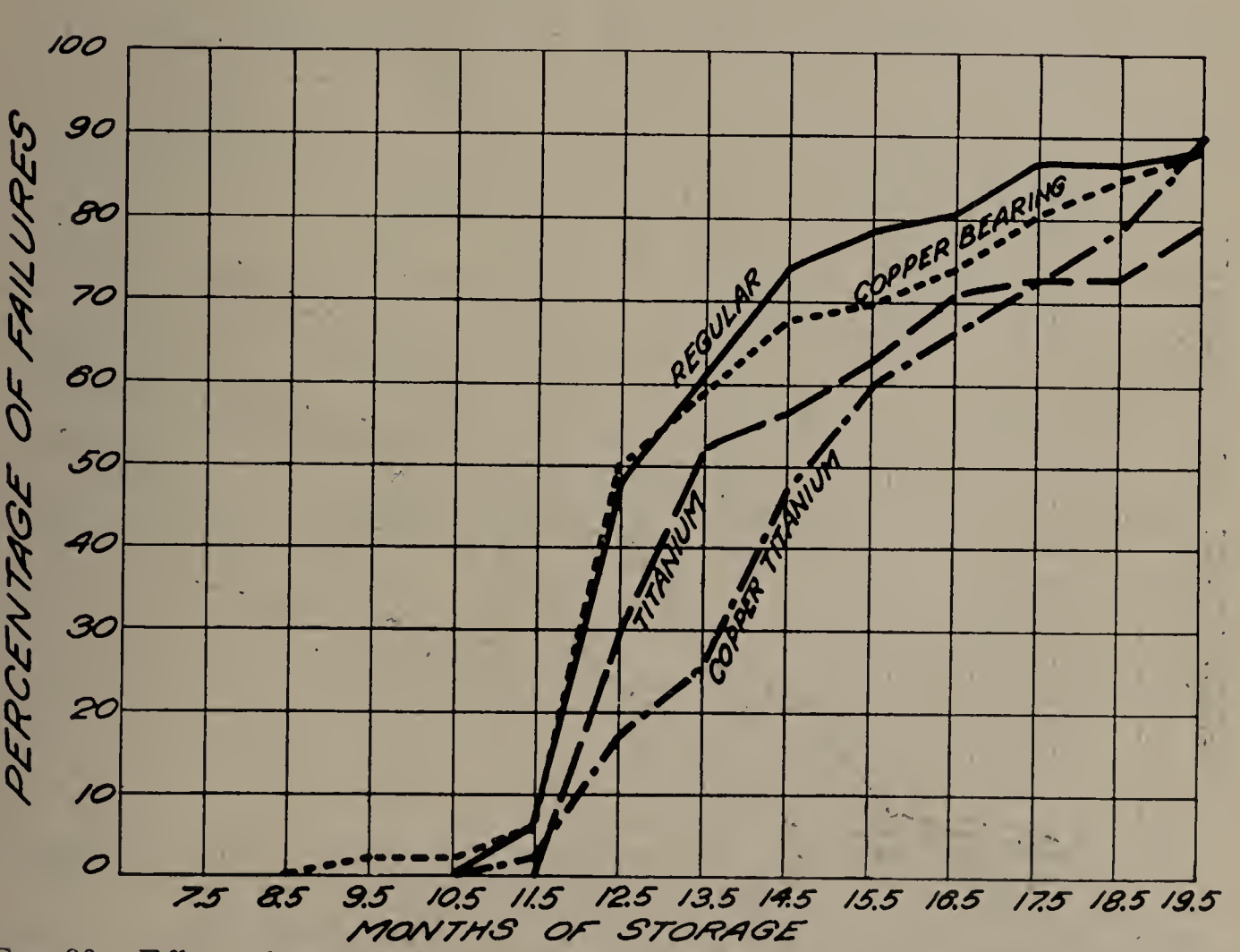


FIG. 90.—Effect of use of titanium; black raspberries in enameled cans, heat 24, 1919 experimental plate (Table 112).

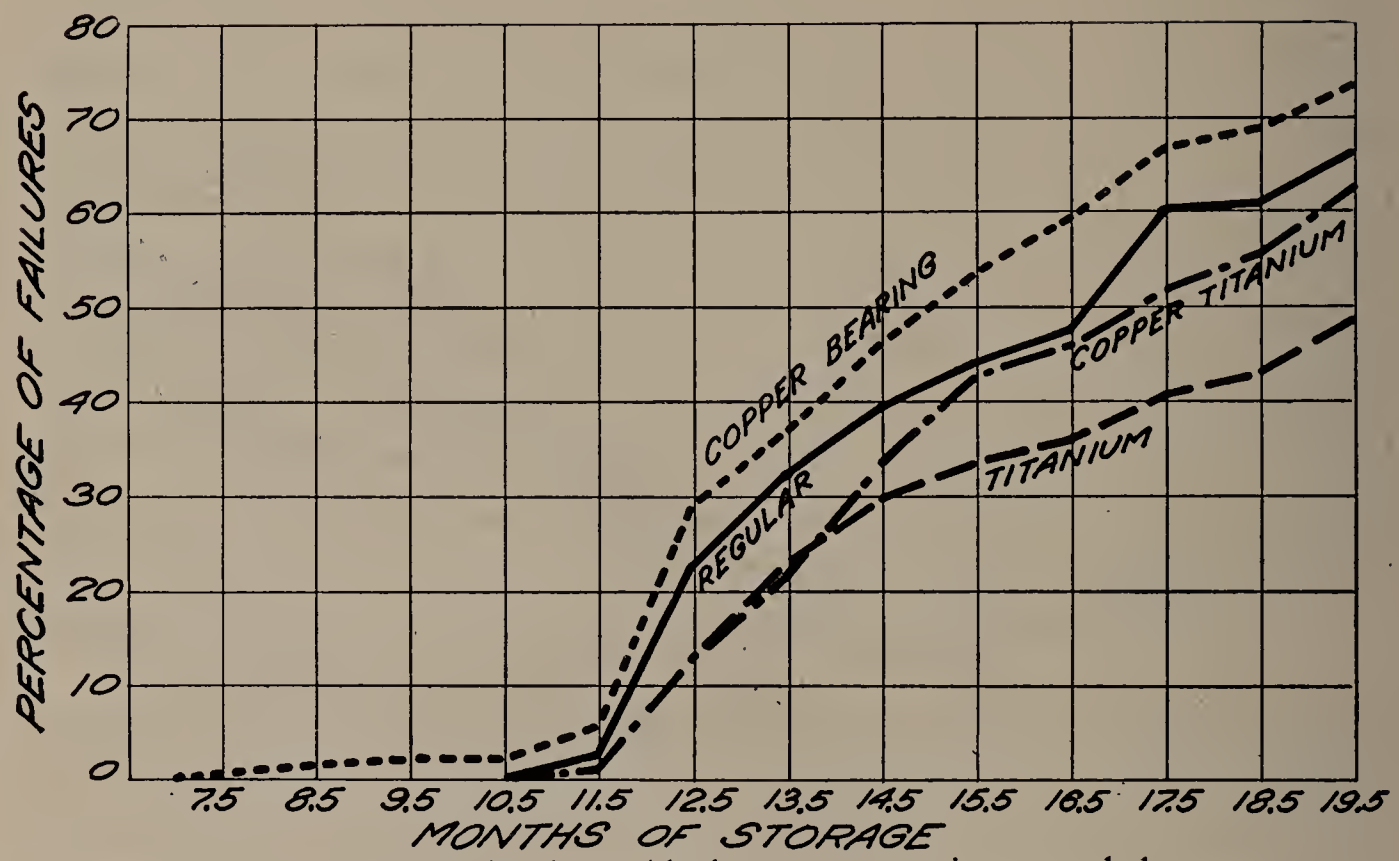


FIG. 91.—Effect of use of titanium; black raspberries in enameled cans, average of all heats, 1919 experimental plate (Table 112).

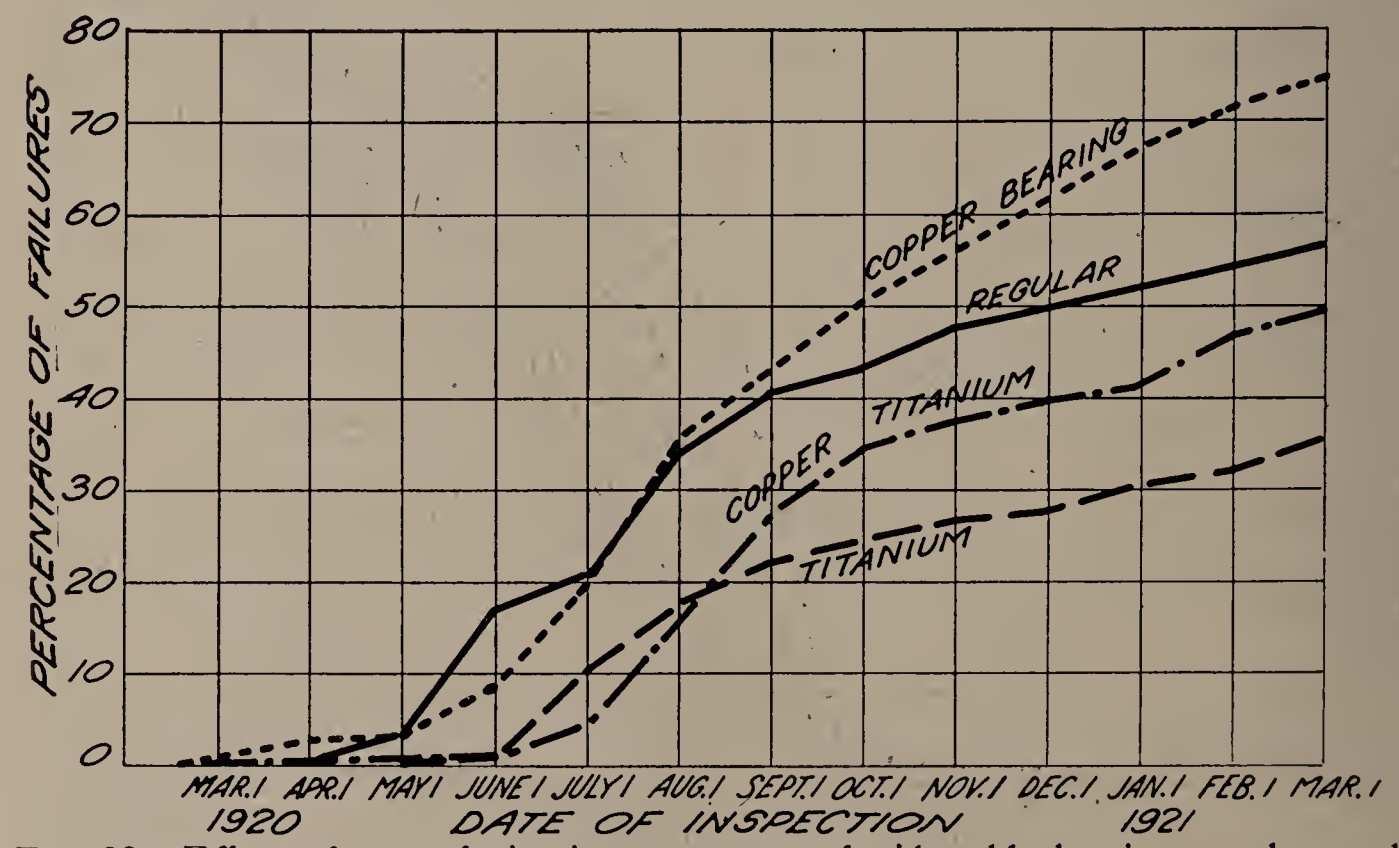


FIG. 92.—Effect of use of titanium; average of cider, blueberries, peaches and black raspberries in enameled cans, heat 21, 1919 experimental plate (Table 113).

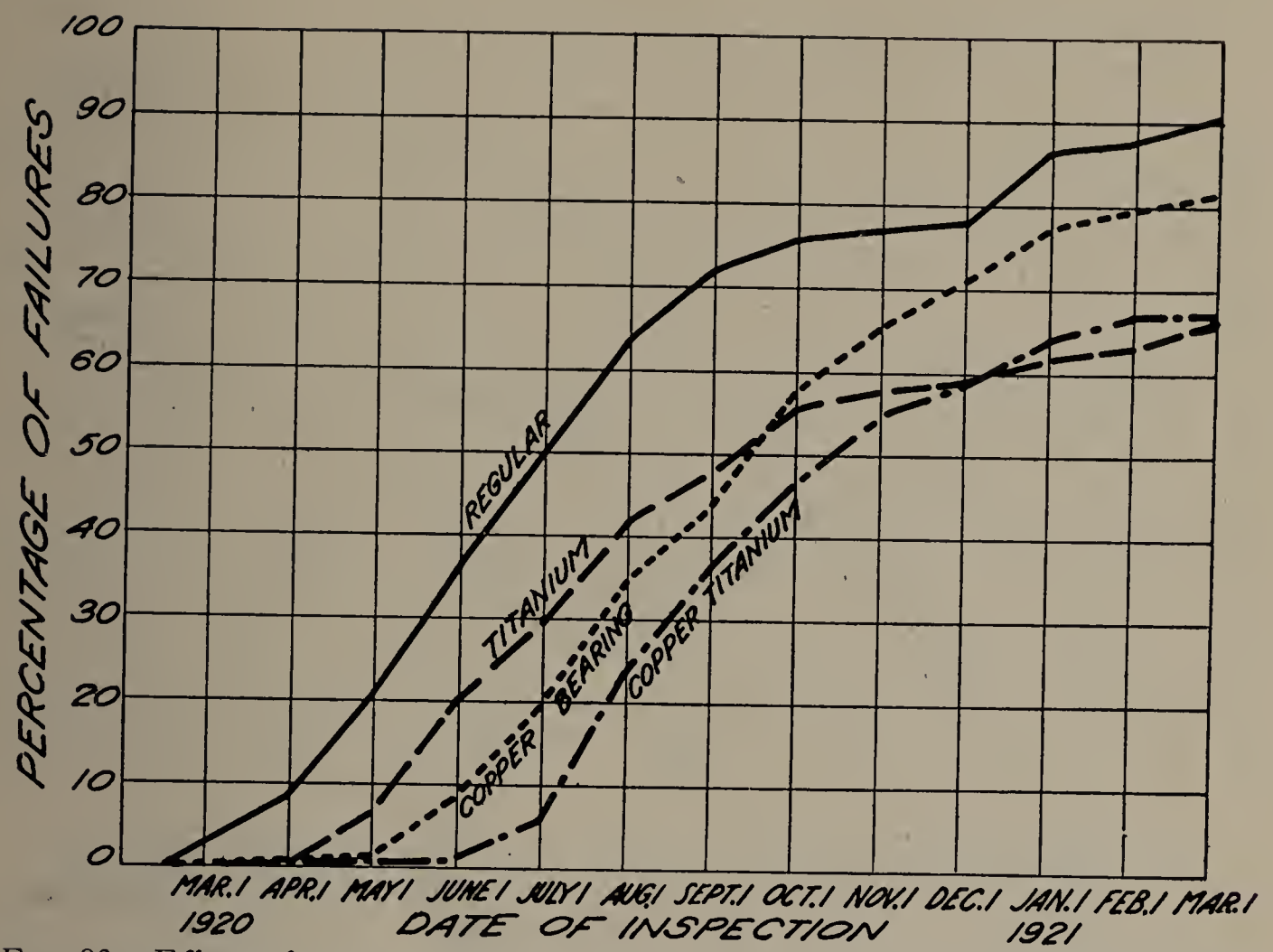


FIG. 93.—Effect of use of titanium; average of cider, blueberries, peaches and black raspberries in enameled cans, heat 22, 1919 experimental plate (Table 113).

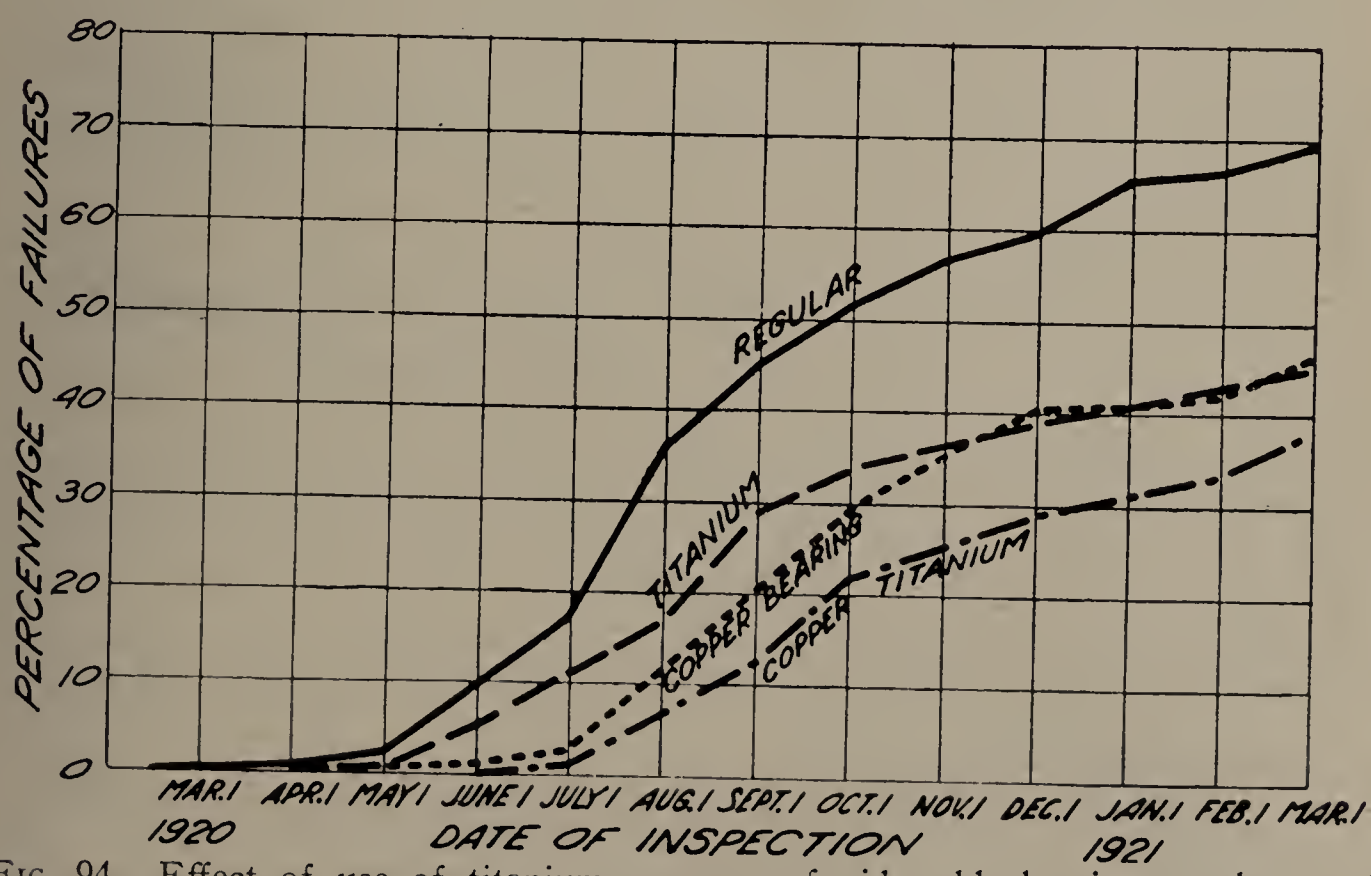


FIG. 94.—Effect of use of titanium, average of cider, blueberries, peaches, and black raspberries, in enameled cans, heat 23, 1919 experimental plate (Table 113).

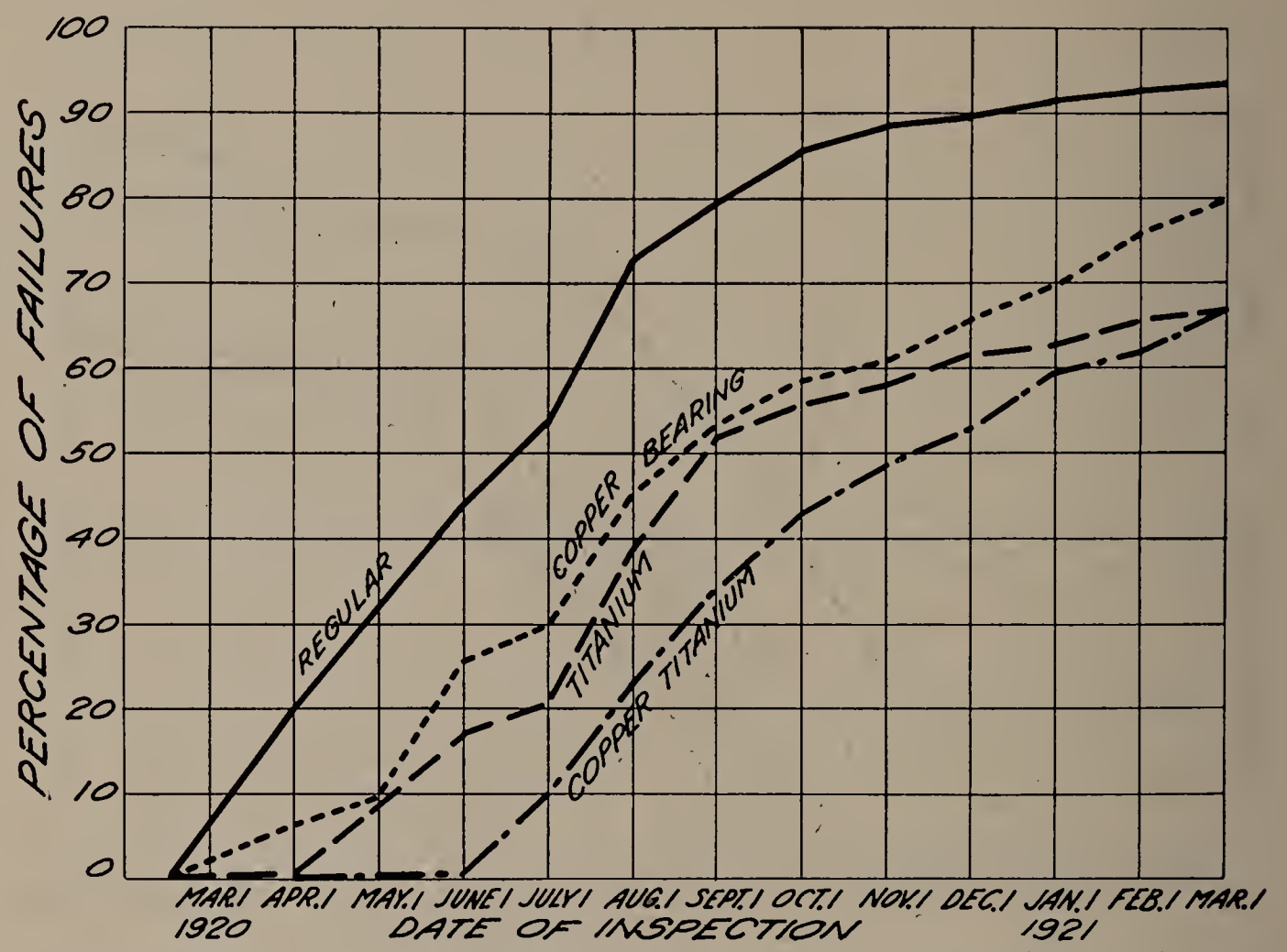


FIG. 95.—Effect of use of titanium; average of cider, blueberries, peaches and black raspberries, in enameled cans, heat 24, 1919 experimental plate (Table 113).

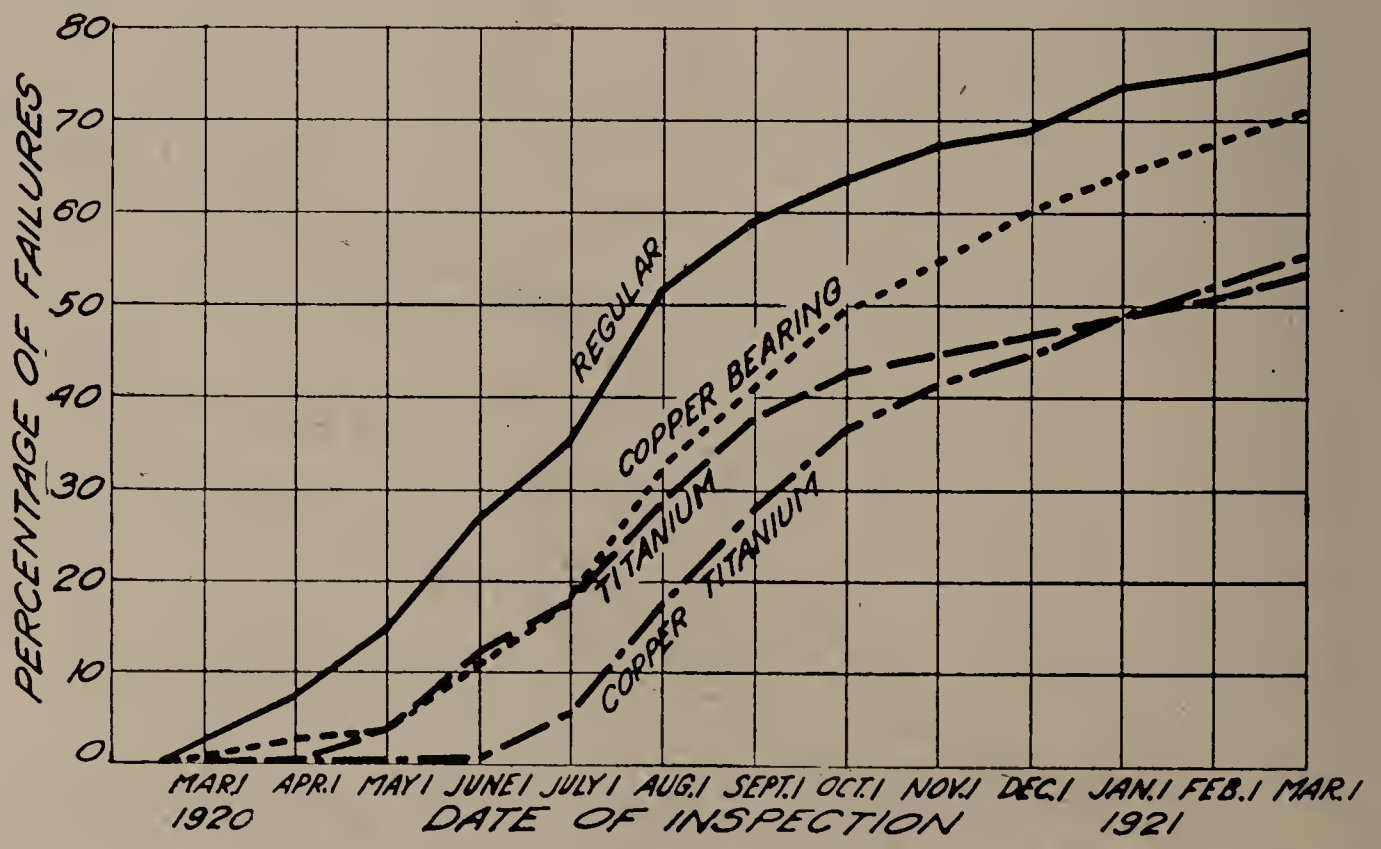


FIG. 96.—Effect of use of titanium; average of cider, blueberries, peaches and black raspberries in enameled cans, average of all heats, 1919 experimental plate (Table 113).

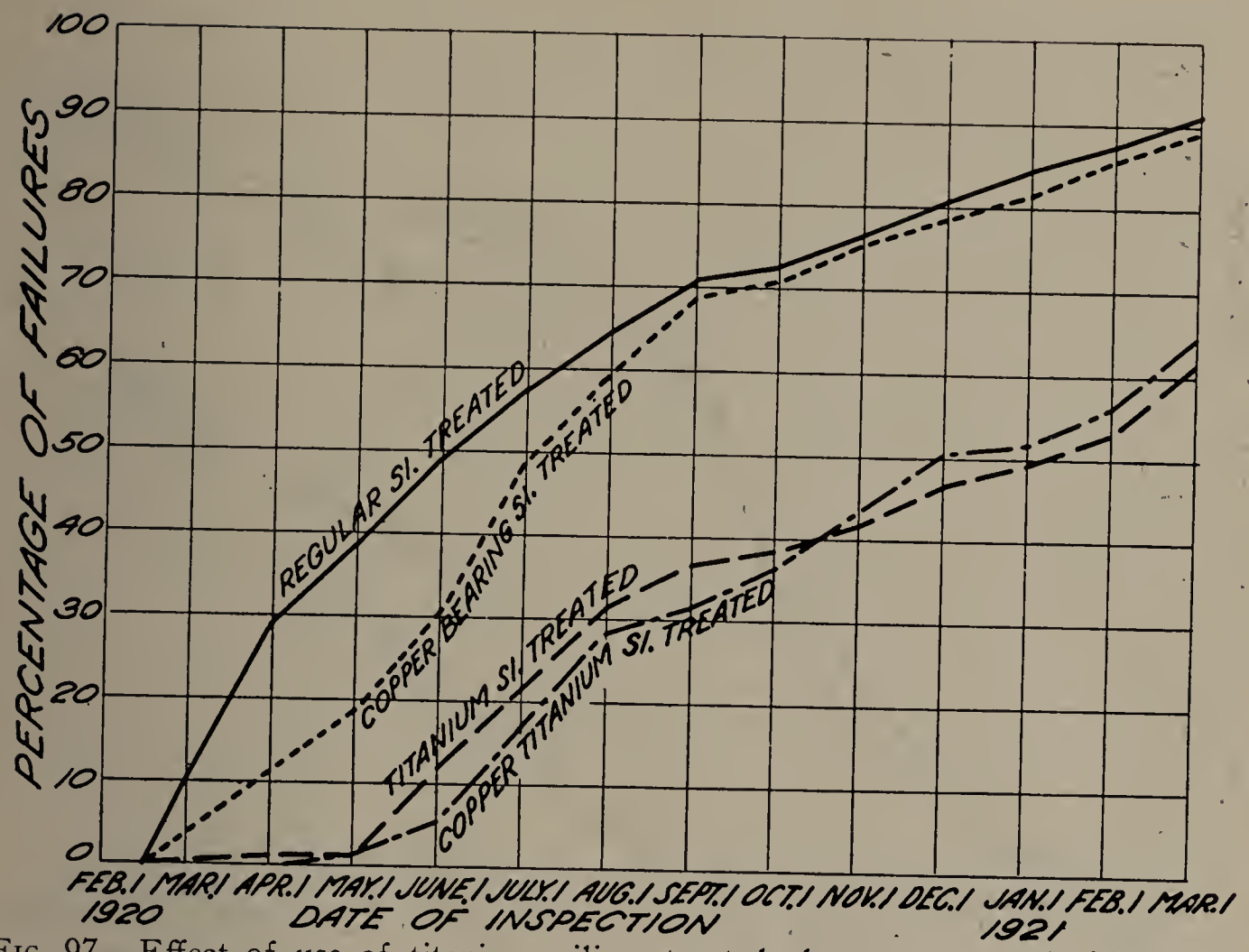


FIG. 97.—Effect of use of titanium, silicon-treated plate; average of cider, blueberries, peaches and black raspberries in enameled cans, heat 21, 1919 experimental plate (Table 114).

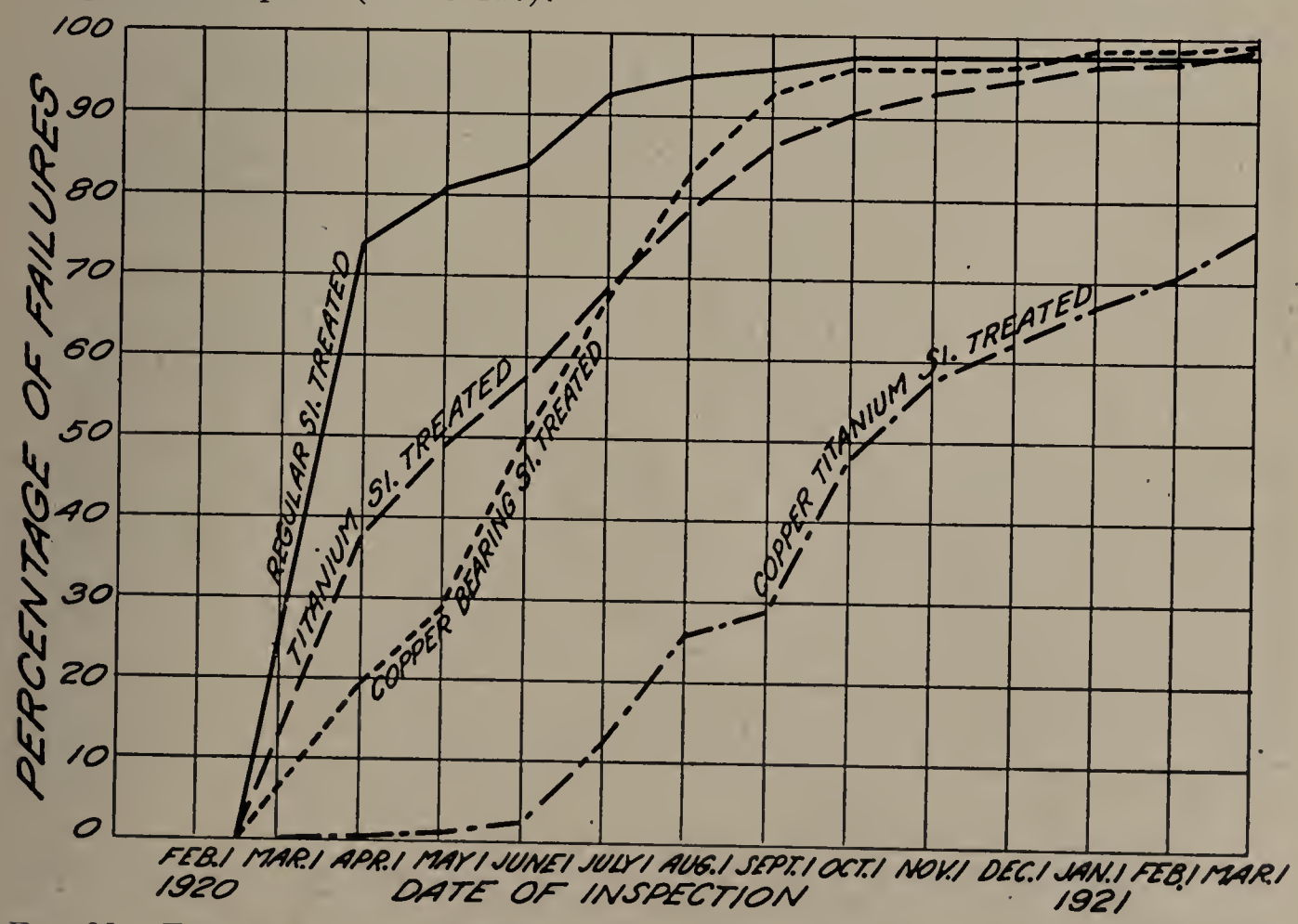


FIG. 98.—Effect of use of titanium, silicon-treated plate; average of cider, blueberries, peaches and black raspberries in enameled cans, heat 22, 1919 experimental plate (Table 114).

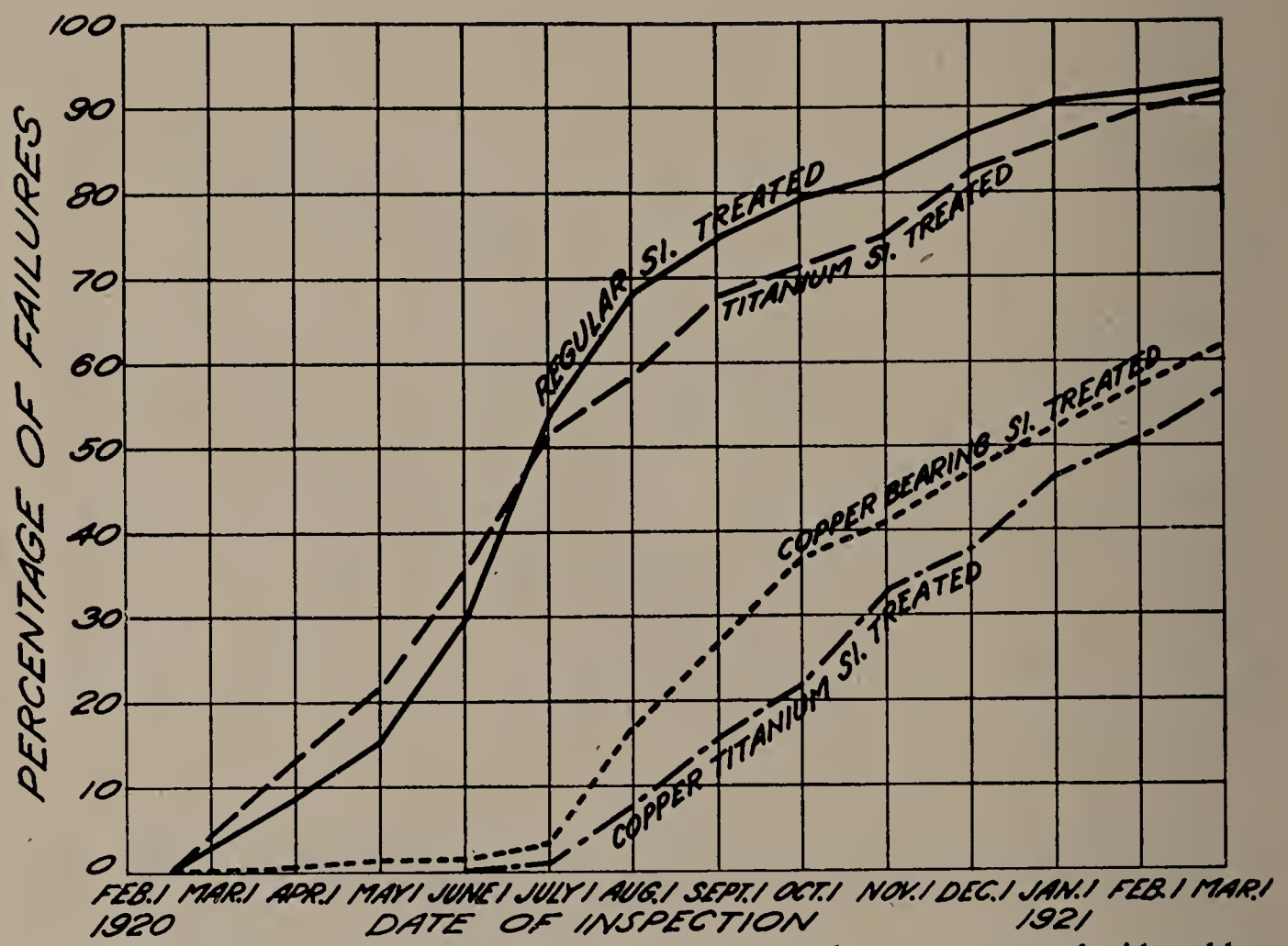


FIG. 99.—Effect of use of titanium, silicon-treated plate; average of cider, blueberries, peaches and black raspberries in enameled cans, heat 23, 1919 experimental plate (Table 114).

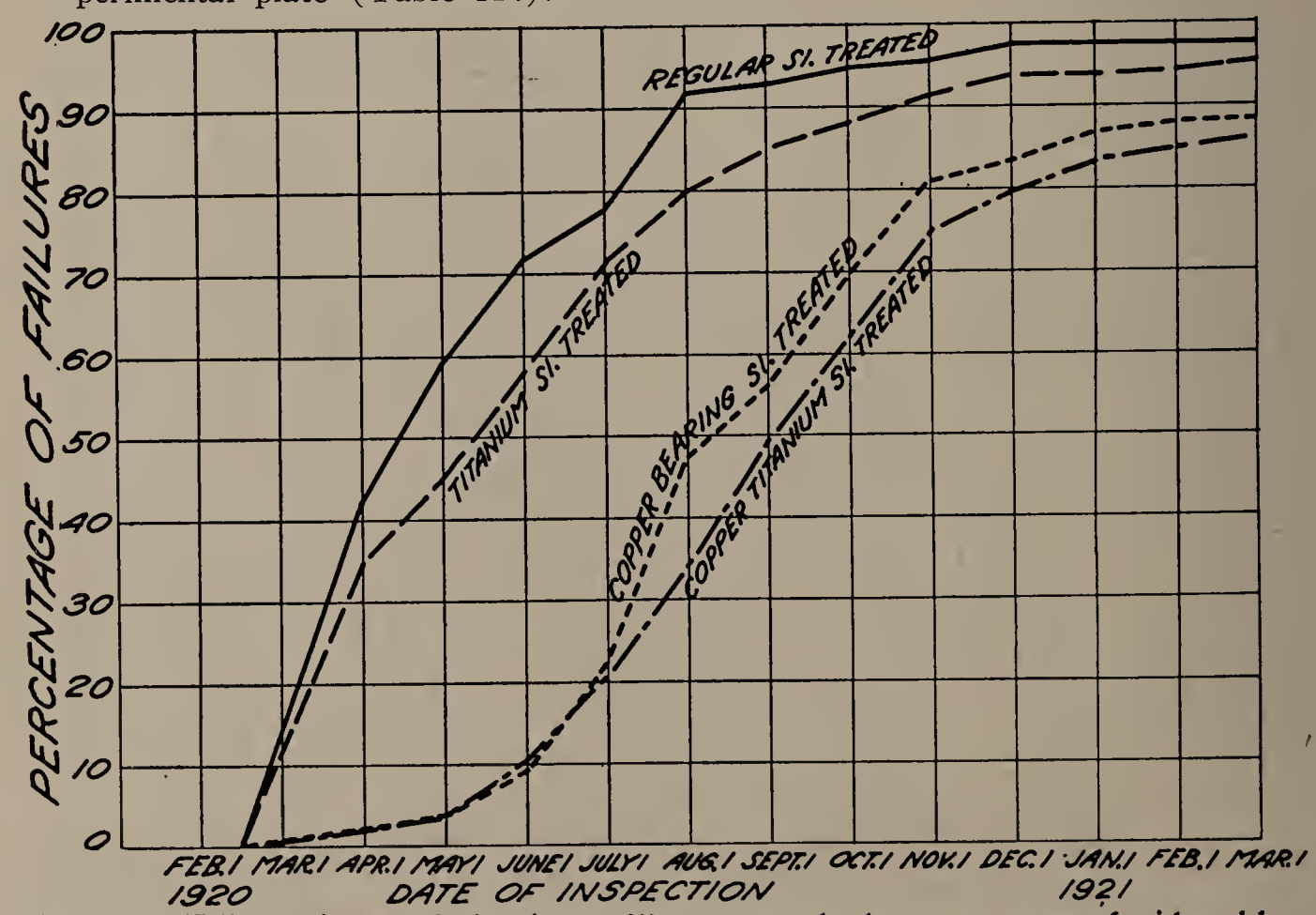


Fig. 100.—Effect of use of titanium, silicon-treated plate; average of cider, blueberries, peaches and black raspberries in enameled cans, heat 24, 1919 experimental plate (Table 114).

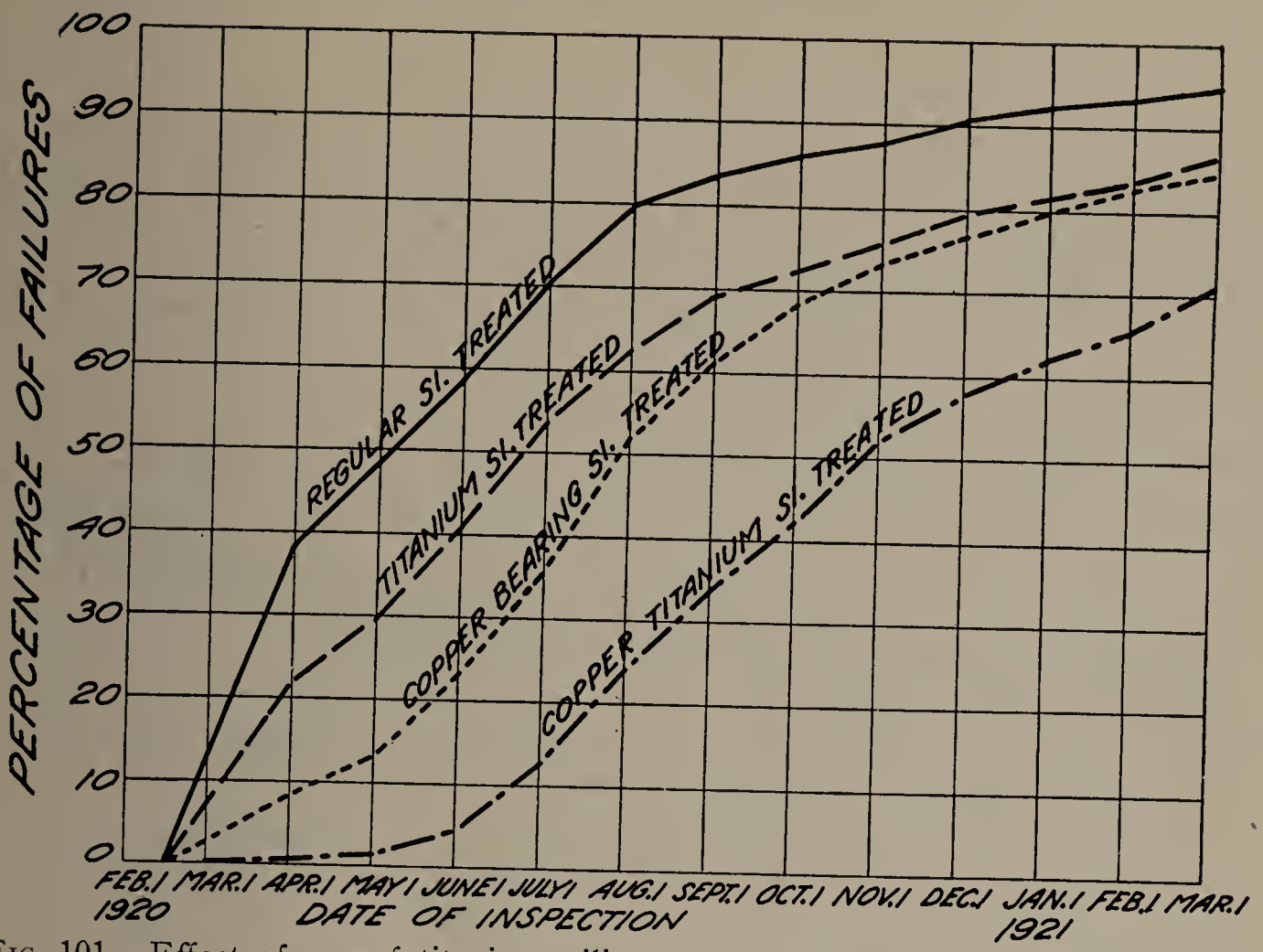


FIG. 101.—Effect of use of titanium, silicon-treated plate; average of cider, blueberries, peaches and black raspberries in enameled cans, average of all heats, 1919 experimental plate (Table 114).

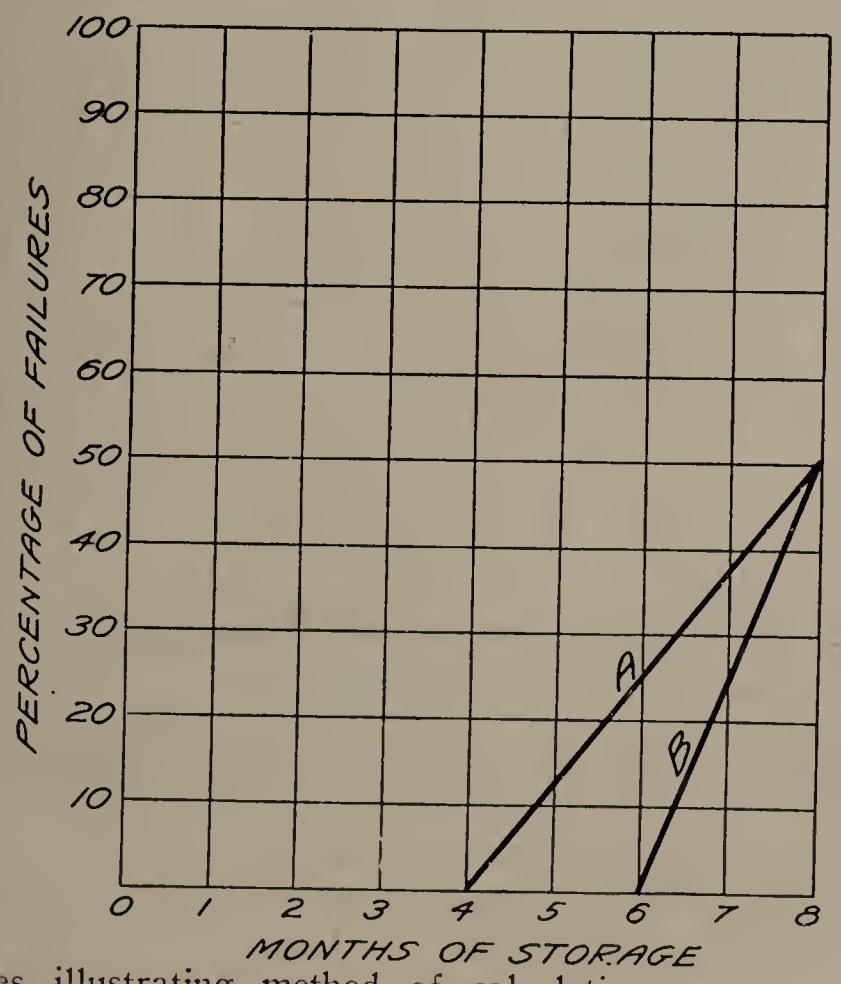


FIG. 102.—Curves illustrating method of calculating percentage service value (See page 132).

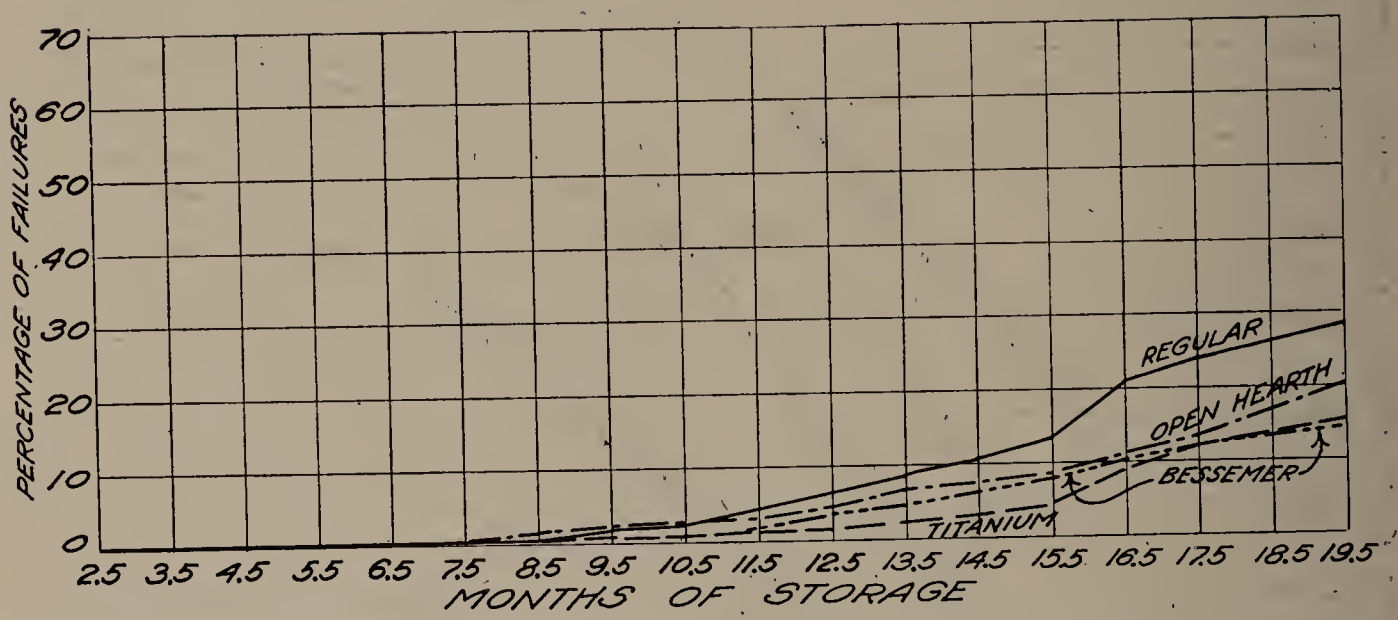


FIG. 103.—Comparison of experimental plate with commercial plate; average of all products in plain cans, coke coating (Table 115).

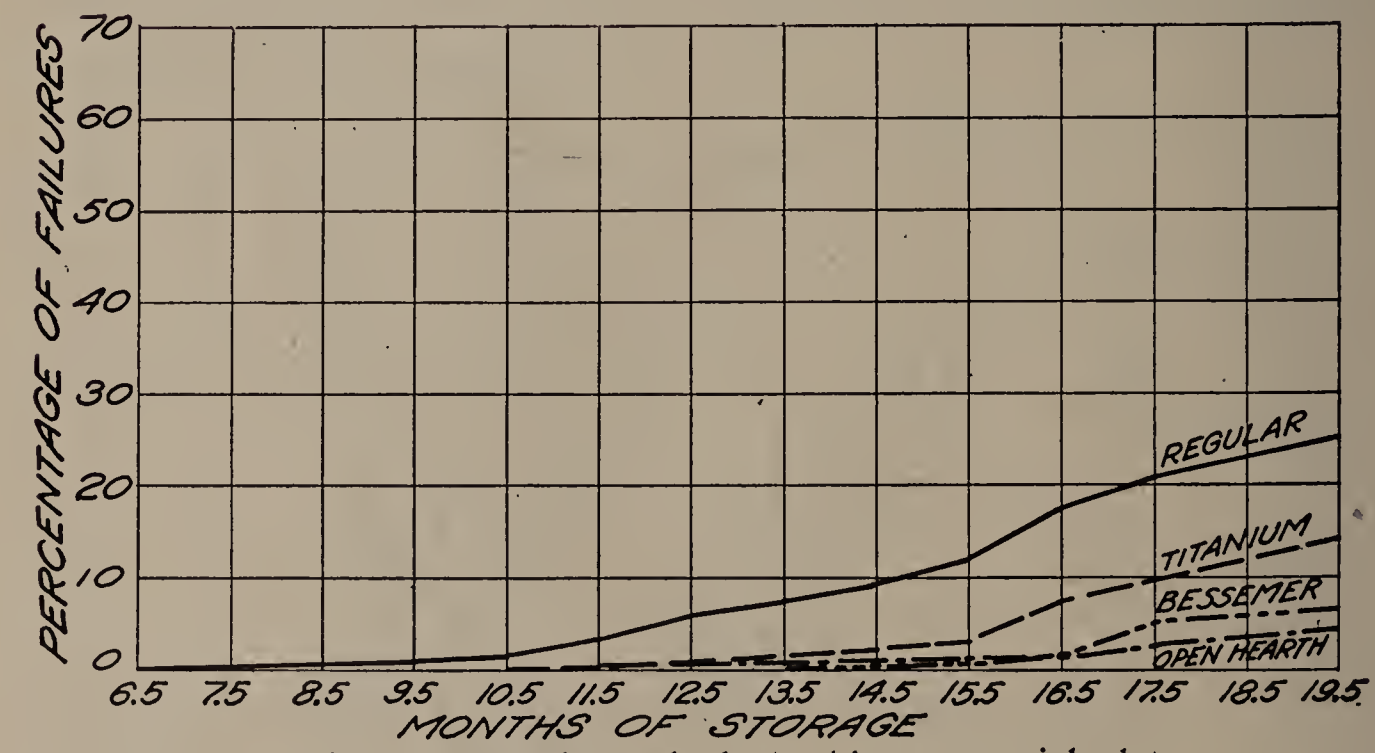


FIG. 104.—Comparison of experimental plate with commercial plate; average of all products in plain cans, charcoal coating (Table 115).

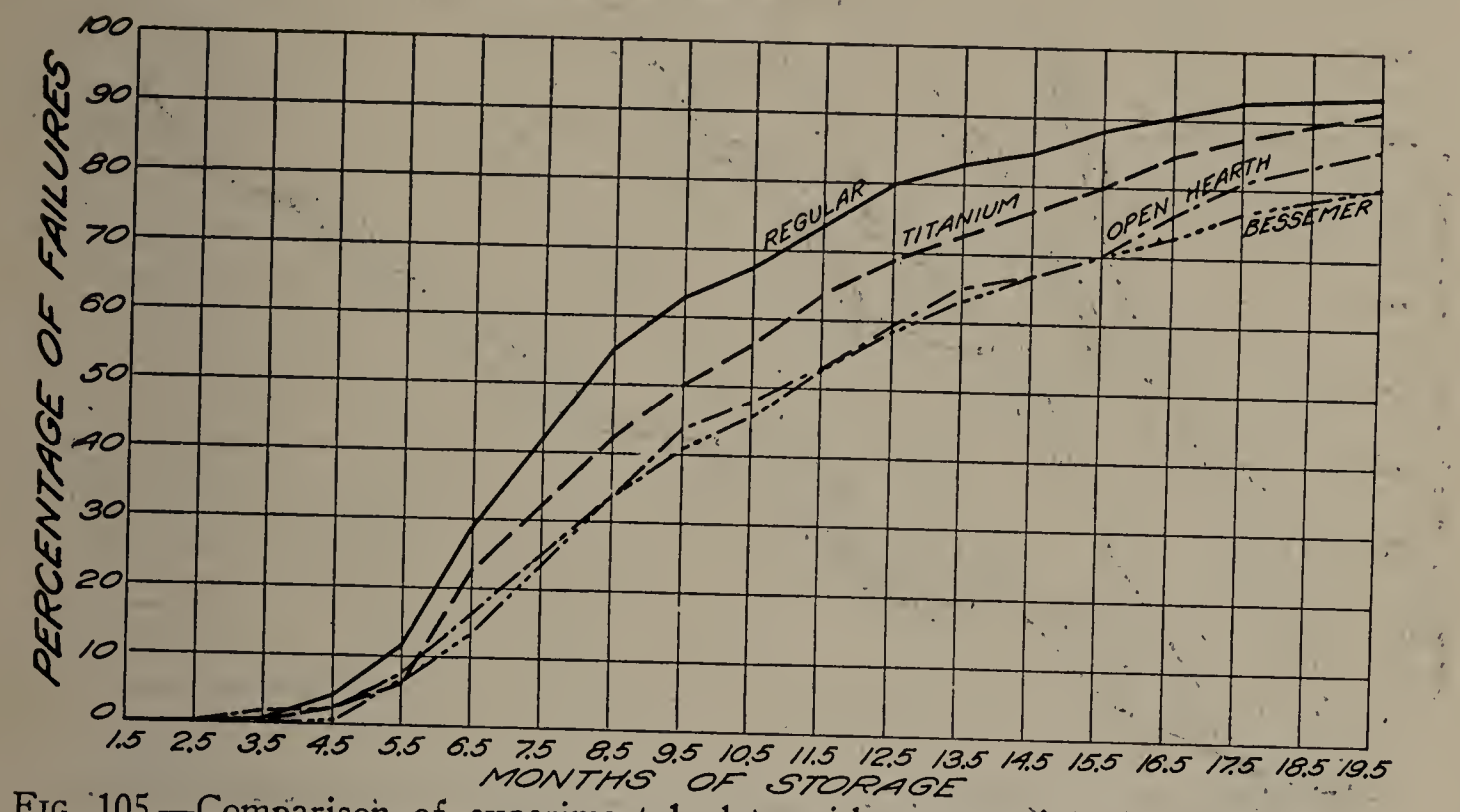


FIG. 105.—Comparison of experimental plate with commercial plate; average of all products in enameled cans, coke coating (Table 115).

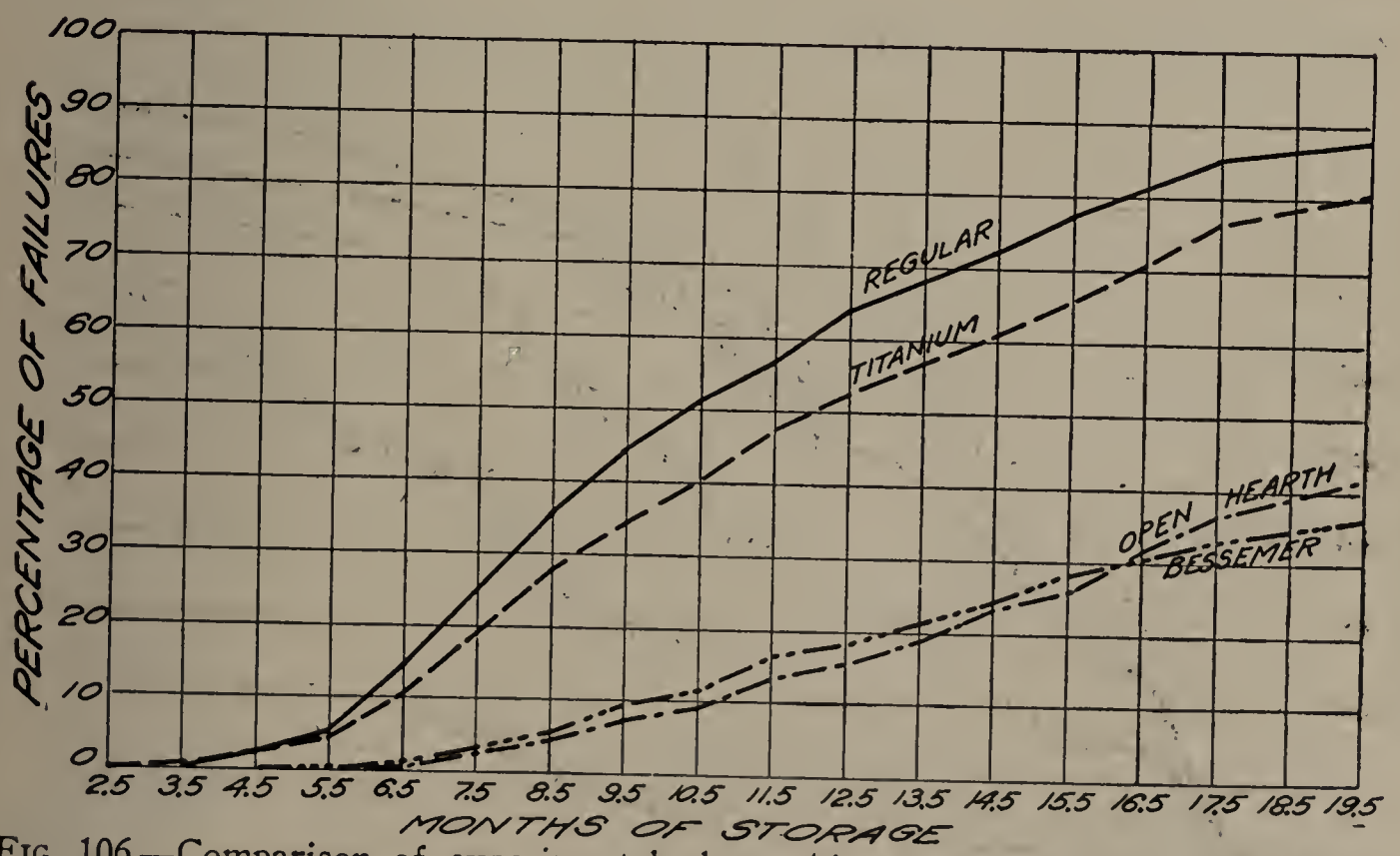


FIG. 106.—Comparison of experimental plate with commercial plate; average of all products in enameled cans, charcoal coating (Table 115).

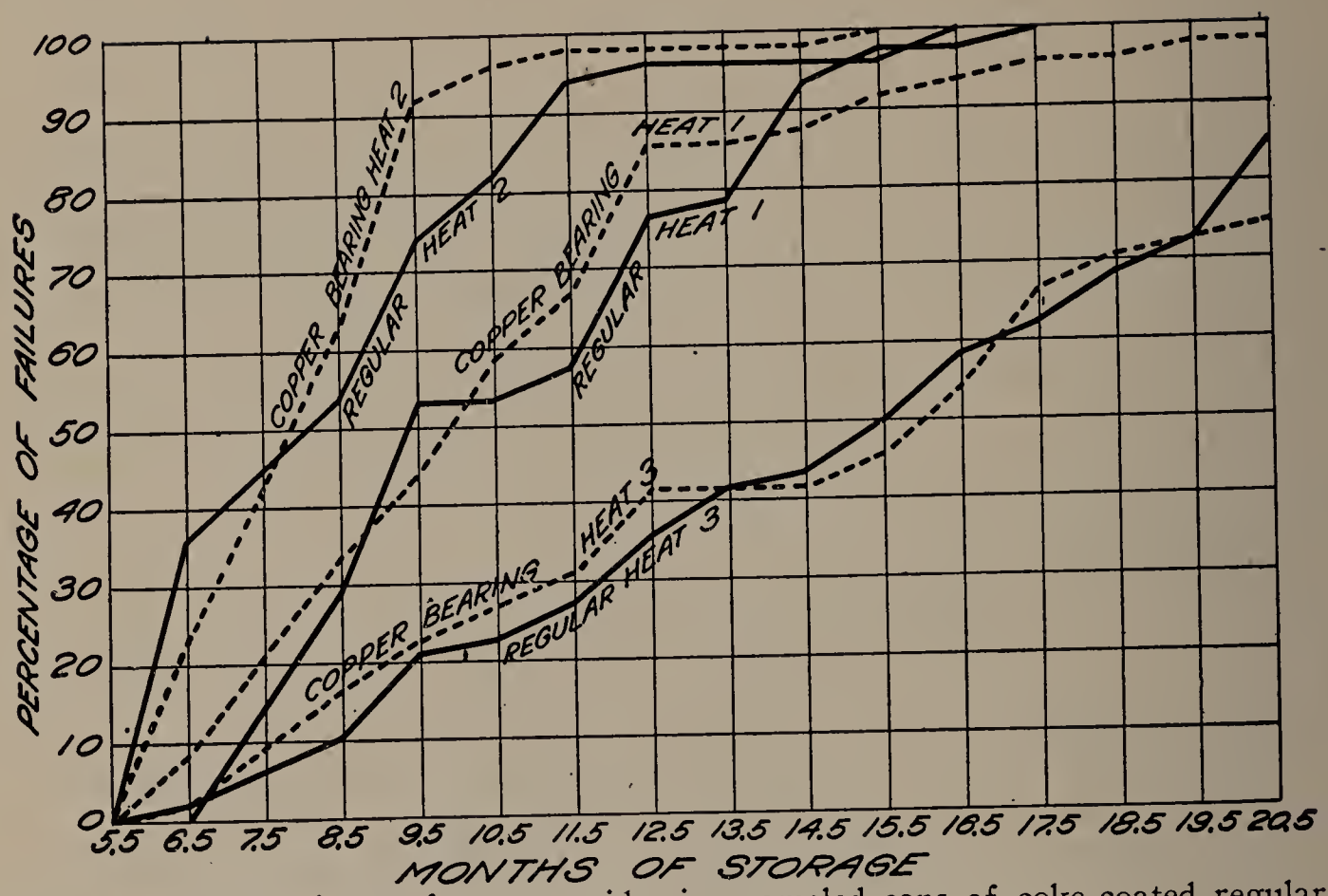


FIG. 107.—Effect of use of copper; cider in enameled cans of coke-coated regular plate of the 1917 experiment (Table 122, page 287).

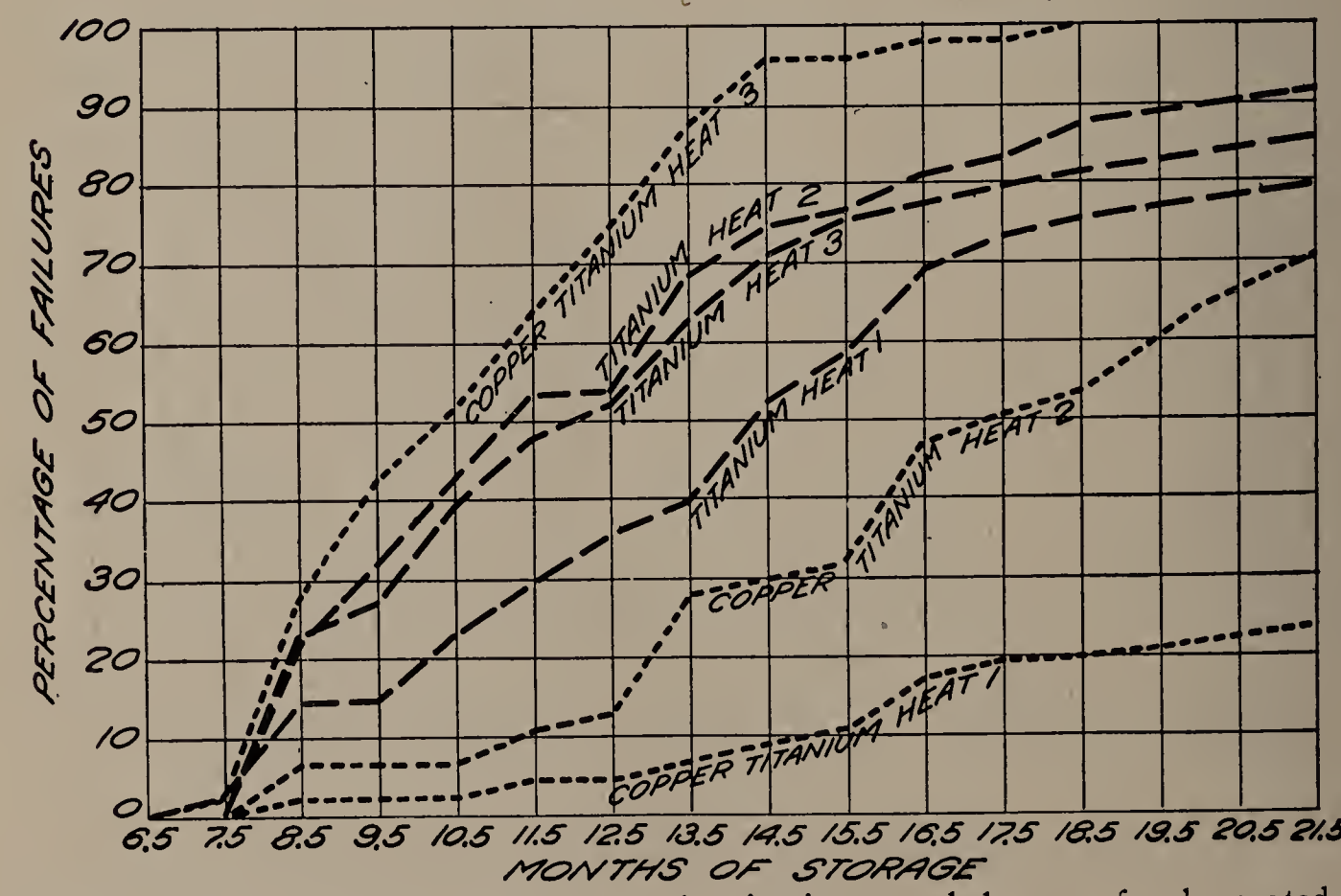


FIG. 108.—Effect of use of copper; strawberries in enameled cans of coke-coated titanium-treated plate of the 1917 experiment (Table 124, page 295).

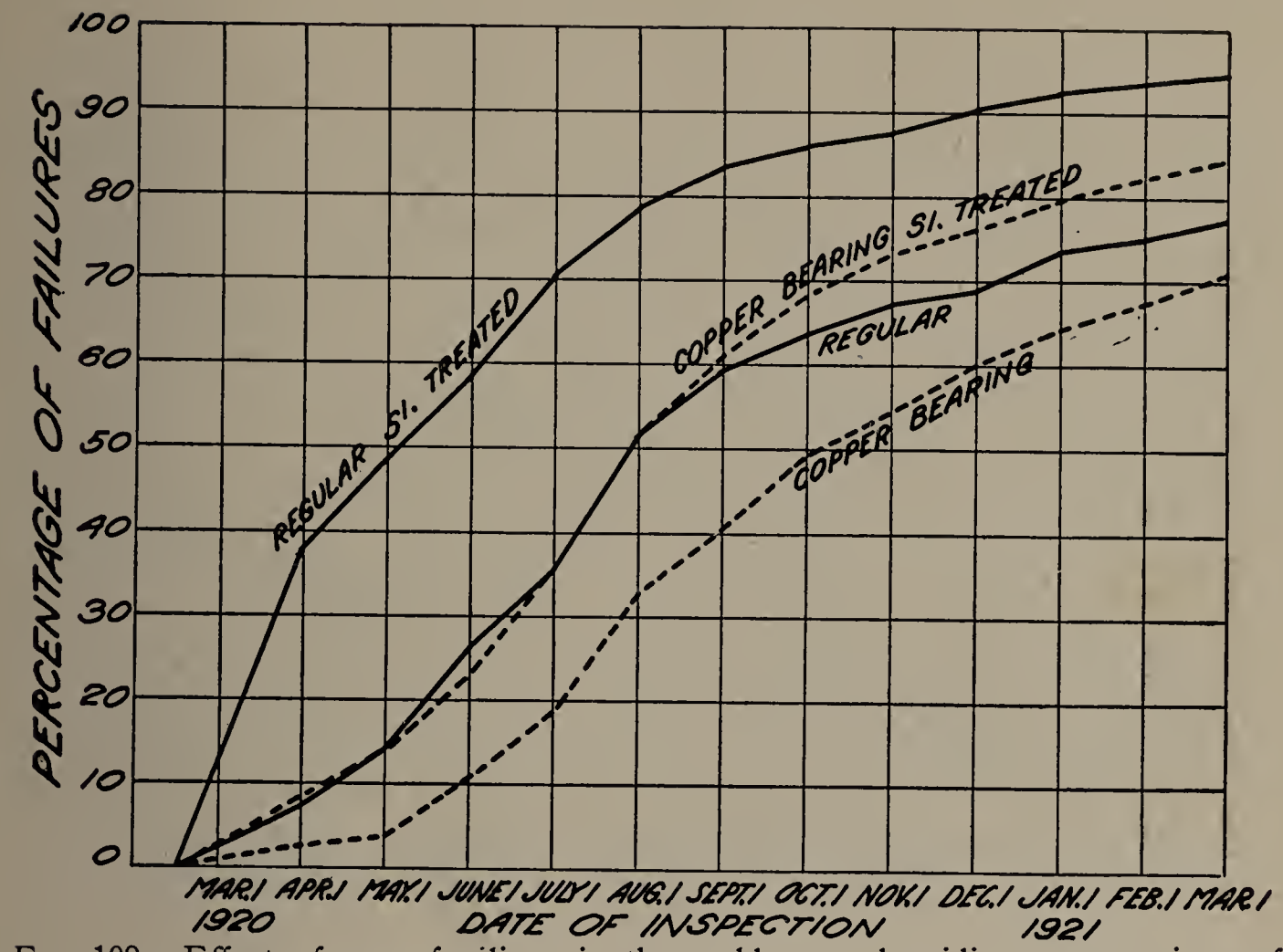


FIG. 109.—Effect of use of silicon in the mold as a deoxidizer; comparison of silicon-treated regular and copper-bearing plate with non-silicon-treated, average of all heats of all products in enameled cans (Table 116).

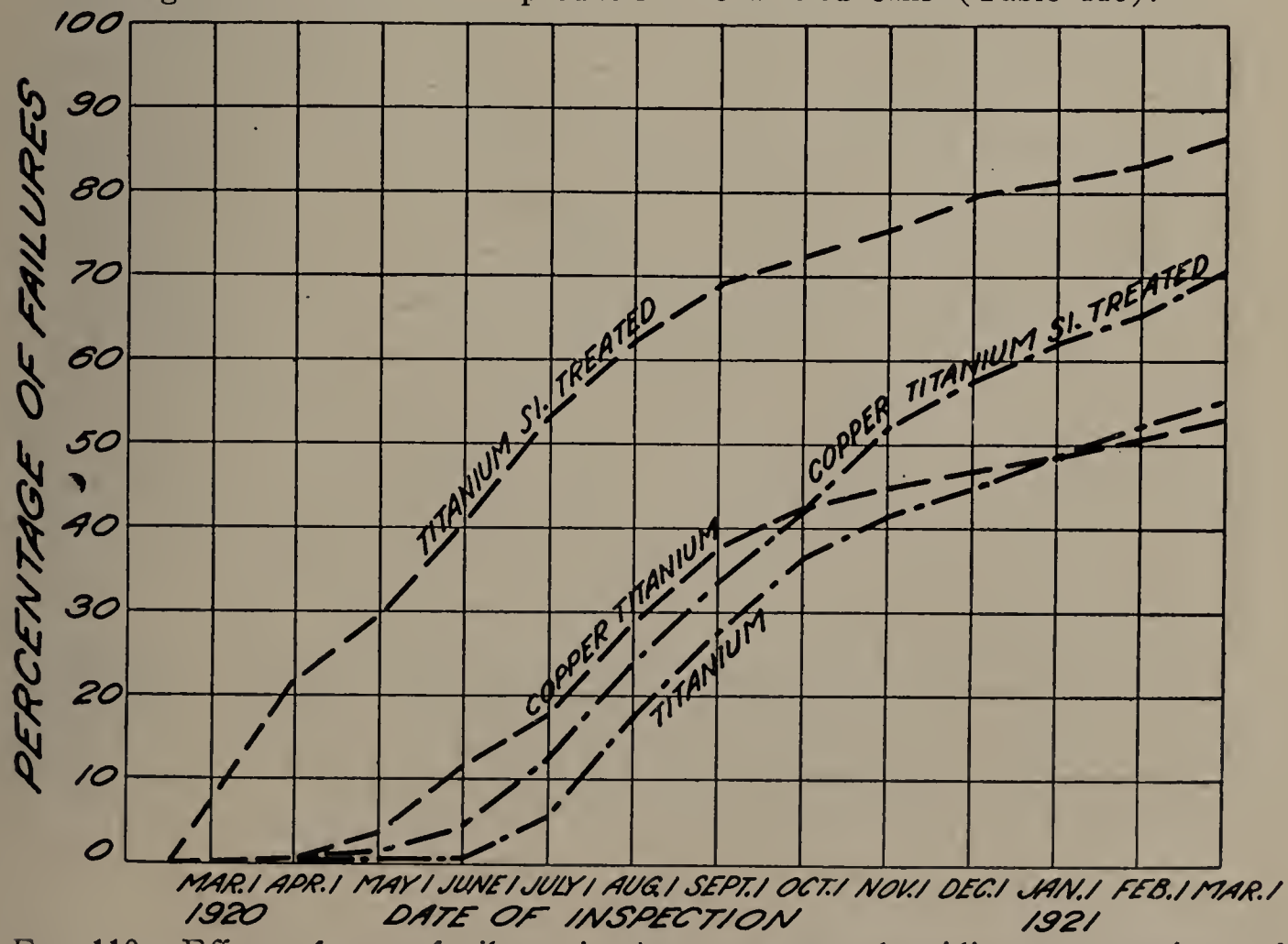


FIG. 110.—Effect of use of silicon in the mold as a deoxidizer; comparison of silicon-treated titanium and copper-titanium plate with non-silicon-treated, average of all heats of all products in enameled cans (Table 116).

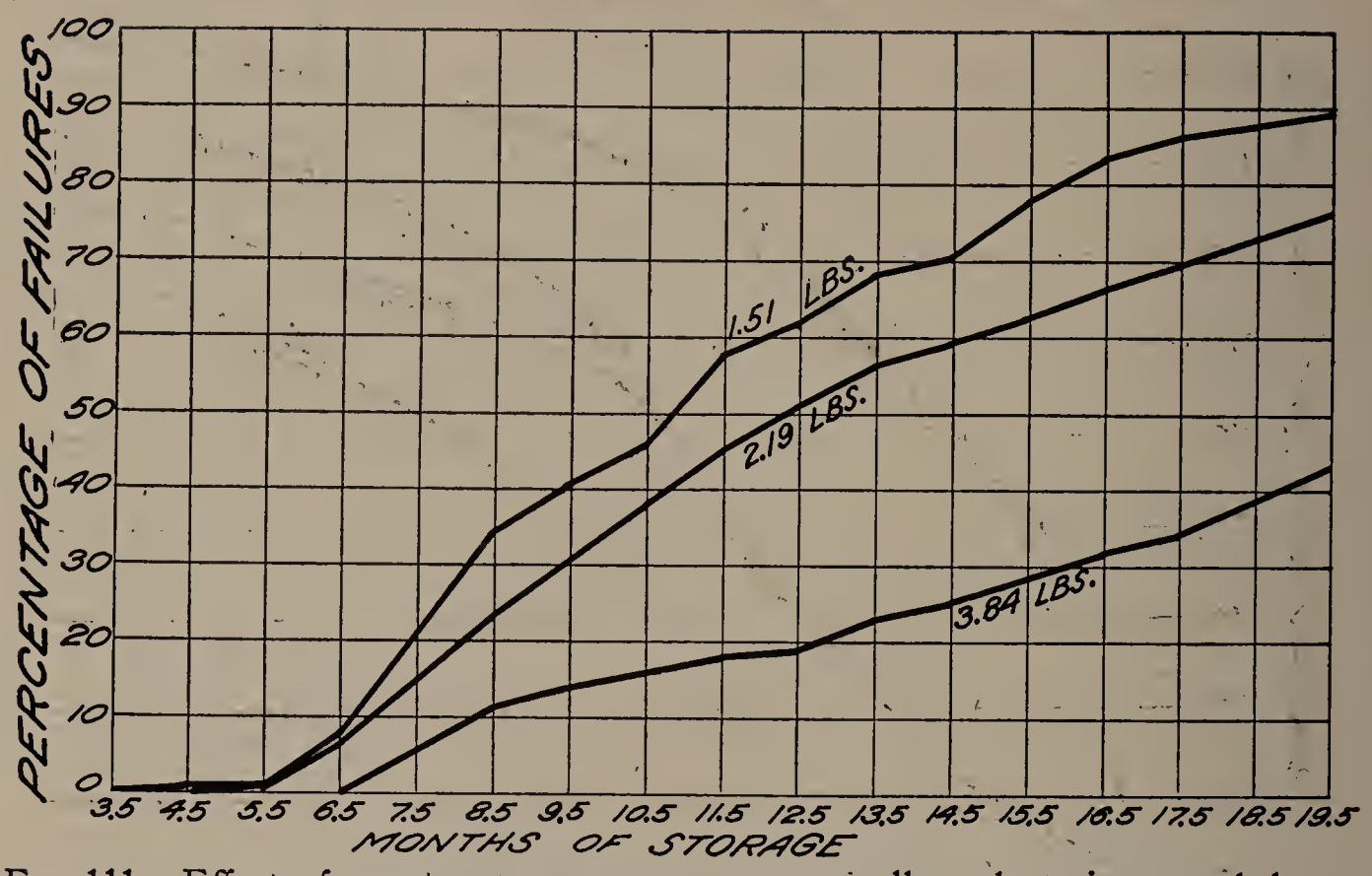


FIG. 111.—Effect of weight of coating; average of all products in enameled cans of heat 3, regular plate (Table 117).

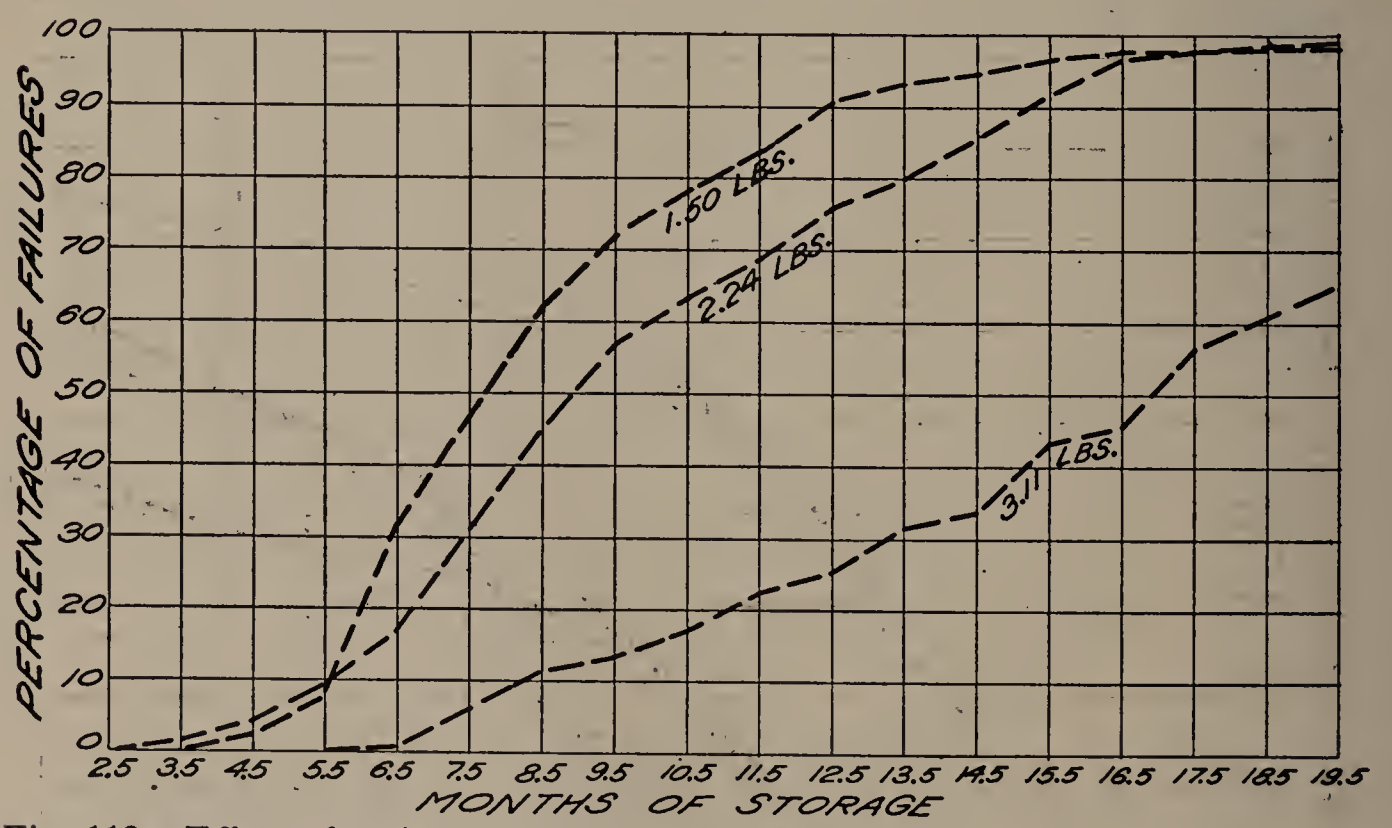


Fig. 112.—Effect of weight of coating; average of all products in enameled cans of heat 4, titanium plate (Table 117).

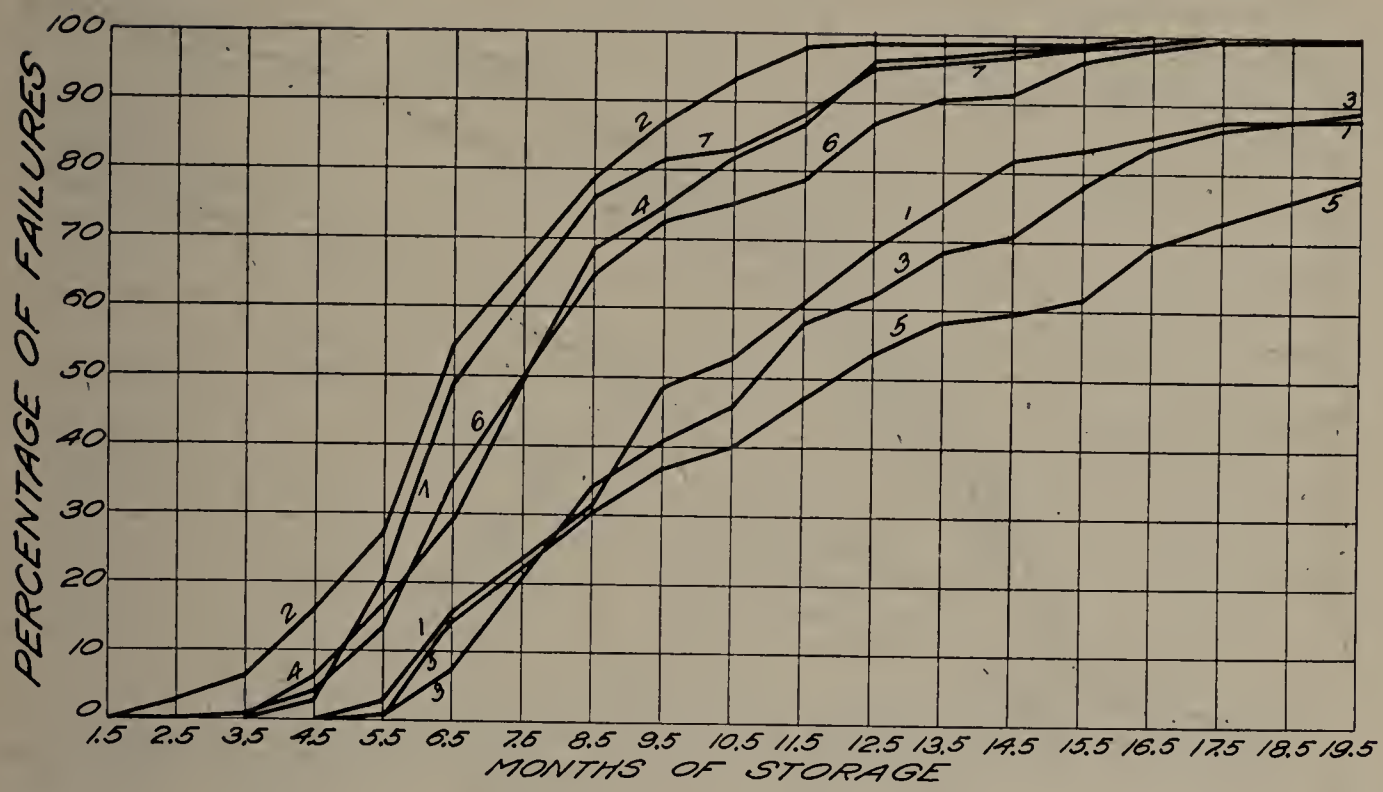


FIG. 113.—Comparison of the seven heats of the 1917 experimental regular plate; average of all products in enameled cans, coke coating (Table 118).

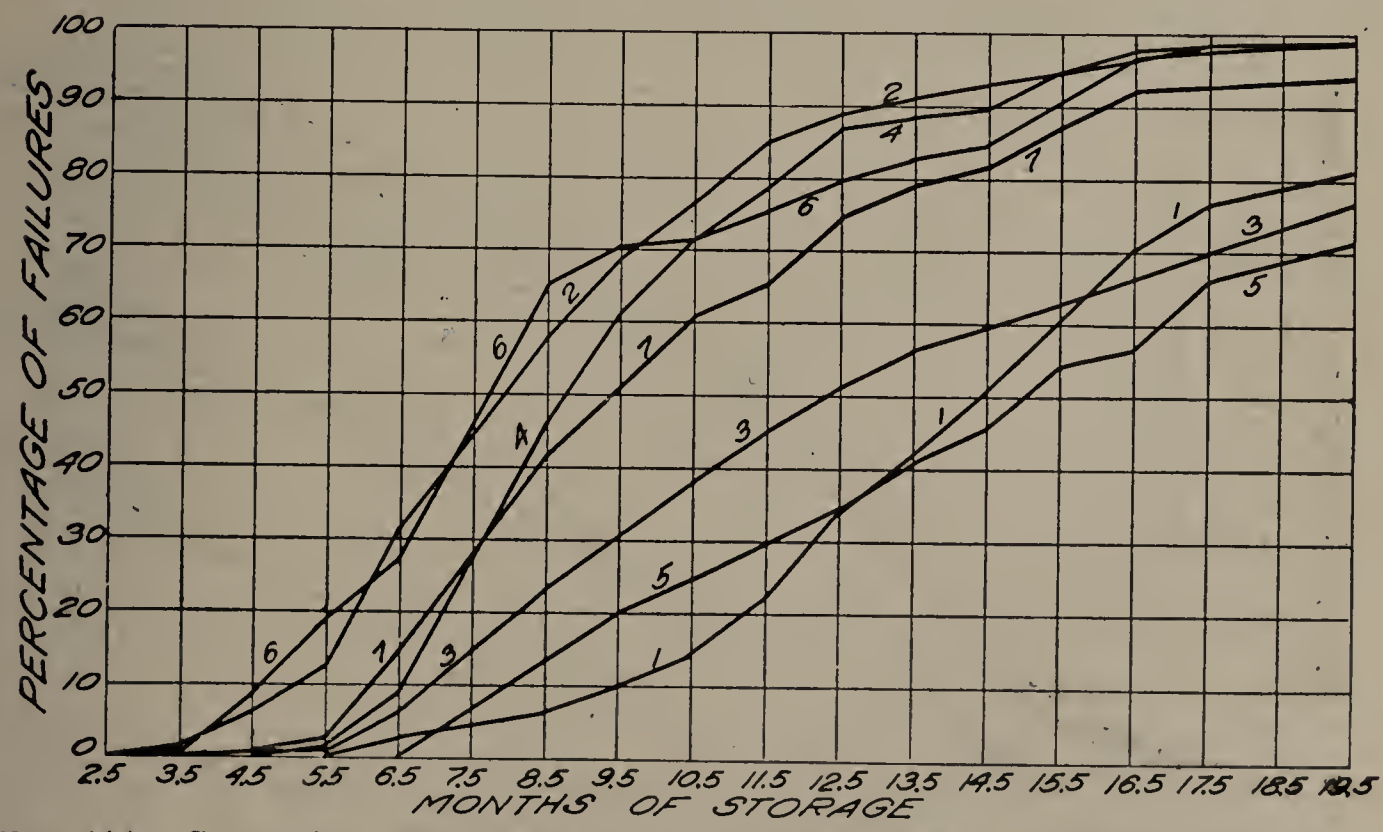


FIG. 114.—Comparison of the seven heats of the 1917 experimental regular plate; average of all products in enameled cans, charcoal coating (Table 118).

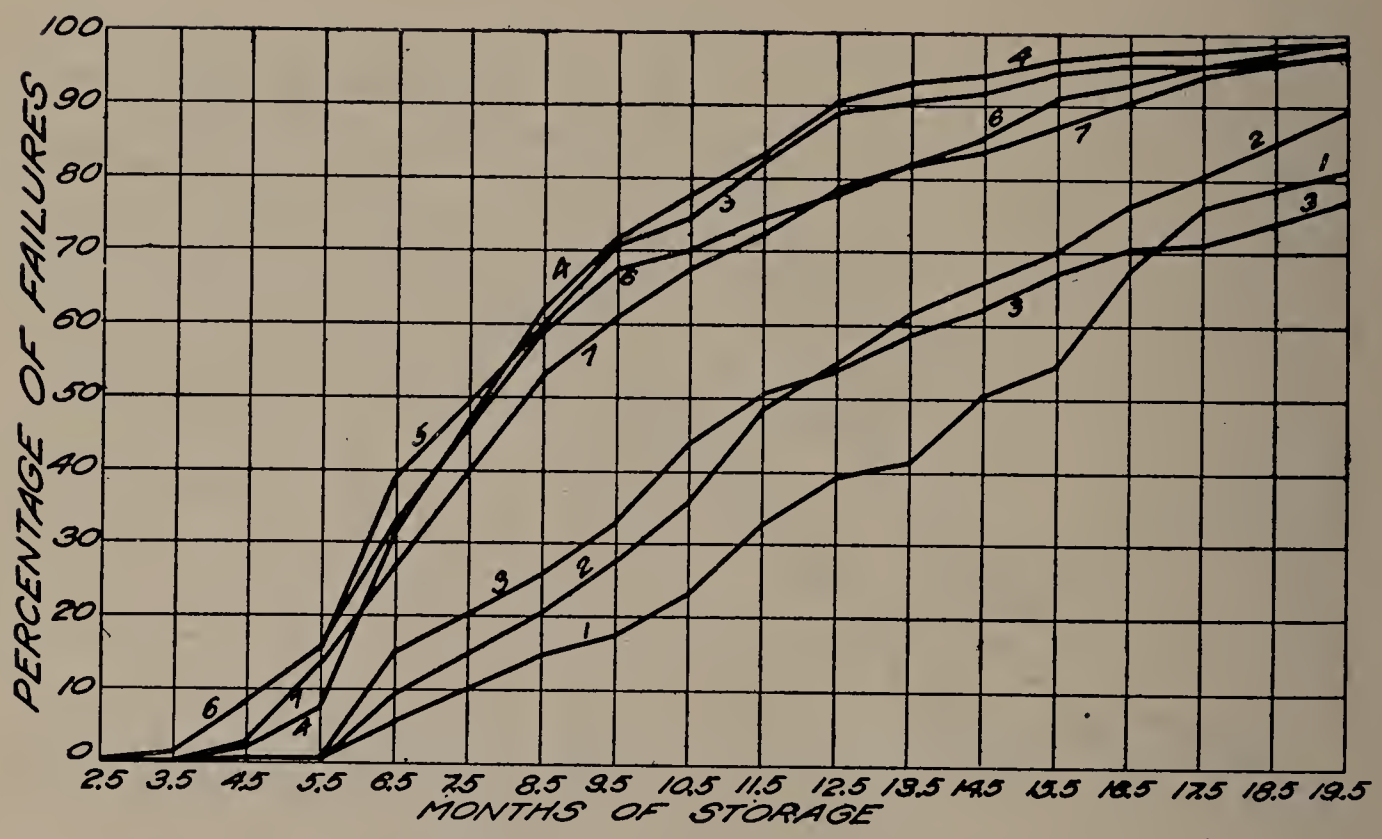


FIG. 115.—Comparison of the seven heats of the 1917 experimental titanium-treated plate; average of all products in enameled cans, coke coating (Table 118).

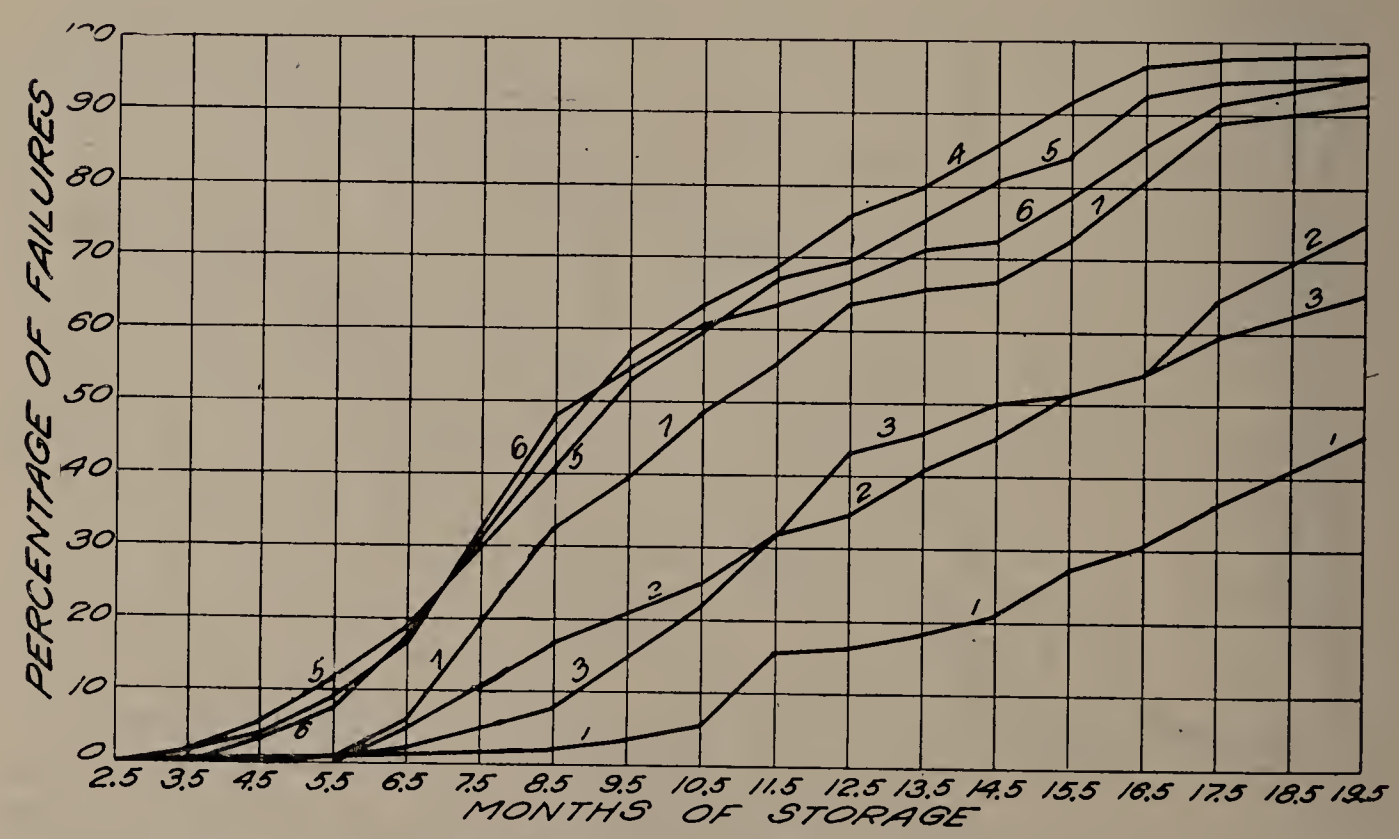


FIG. 116.—Comparison of the seven heats of the 1917 experimental titanium-treated plate; average of all products in enameled cans, charcoal coating (Table 118).

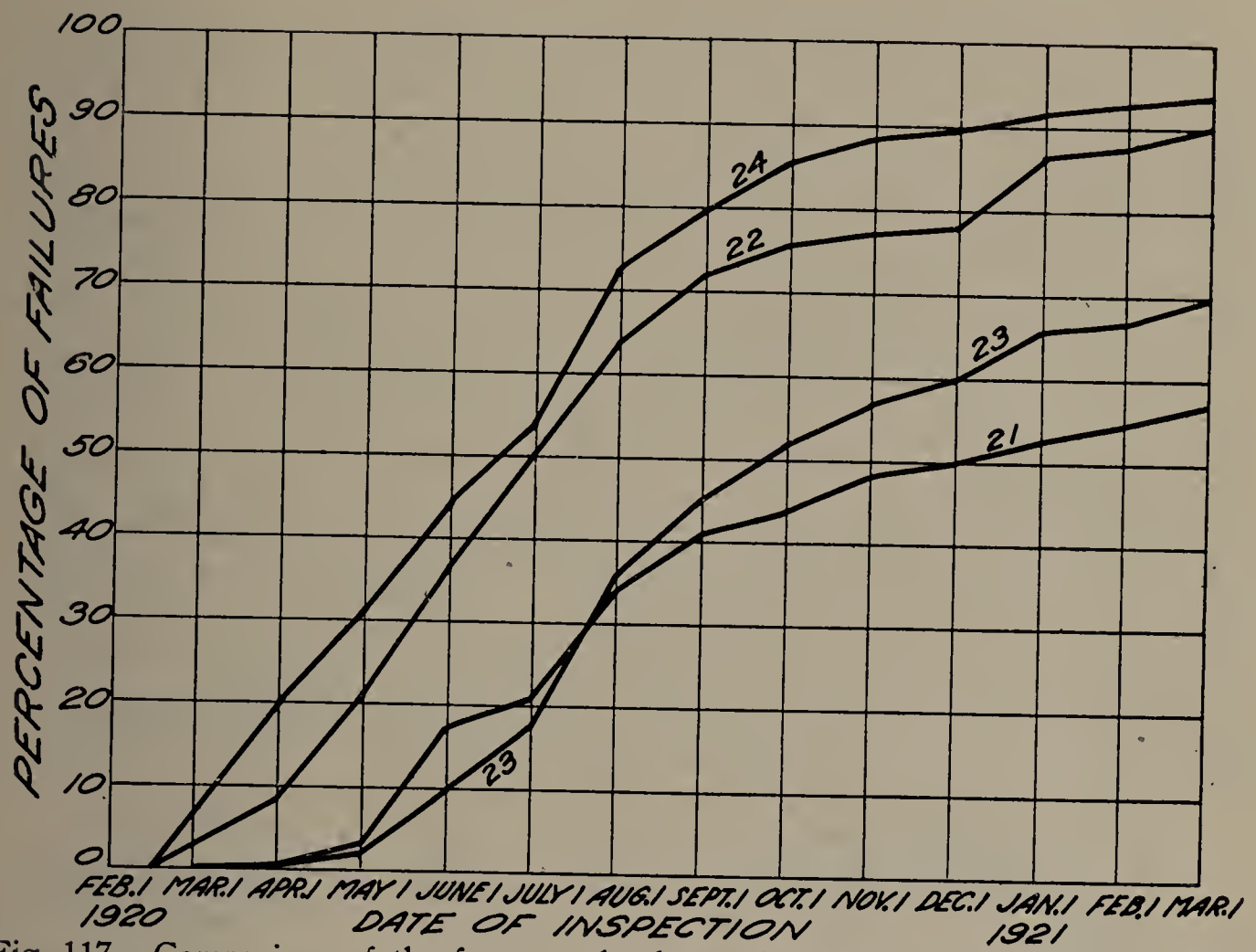


Fig. 117.—Comparison of the four regular heats, 1919 experimental plate; average of all products in enameled cans (Table 119).

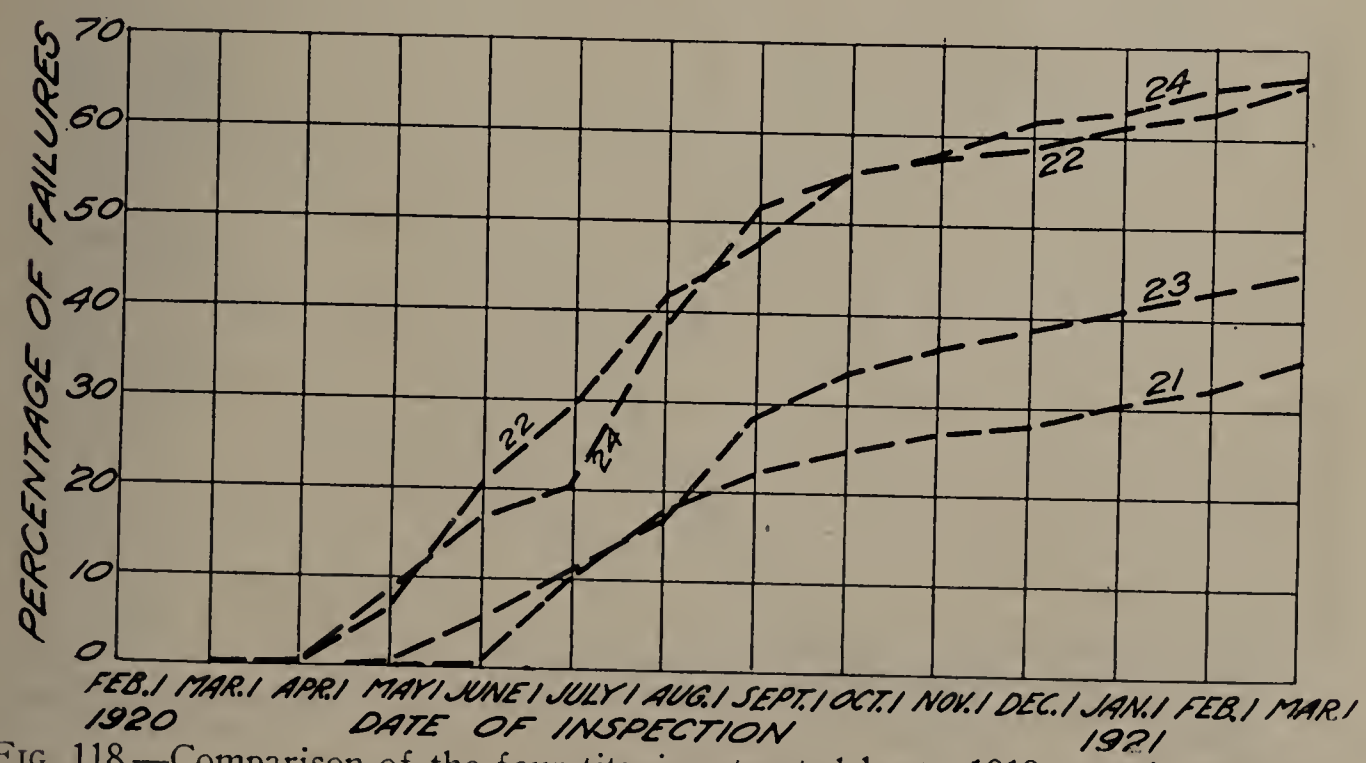


FIG. 118.—Comparison of the four titanium-treated heats, 1919 experimental plate; average of all products in enameled cans (Table 119).

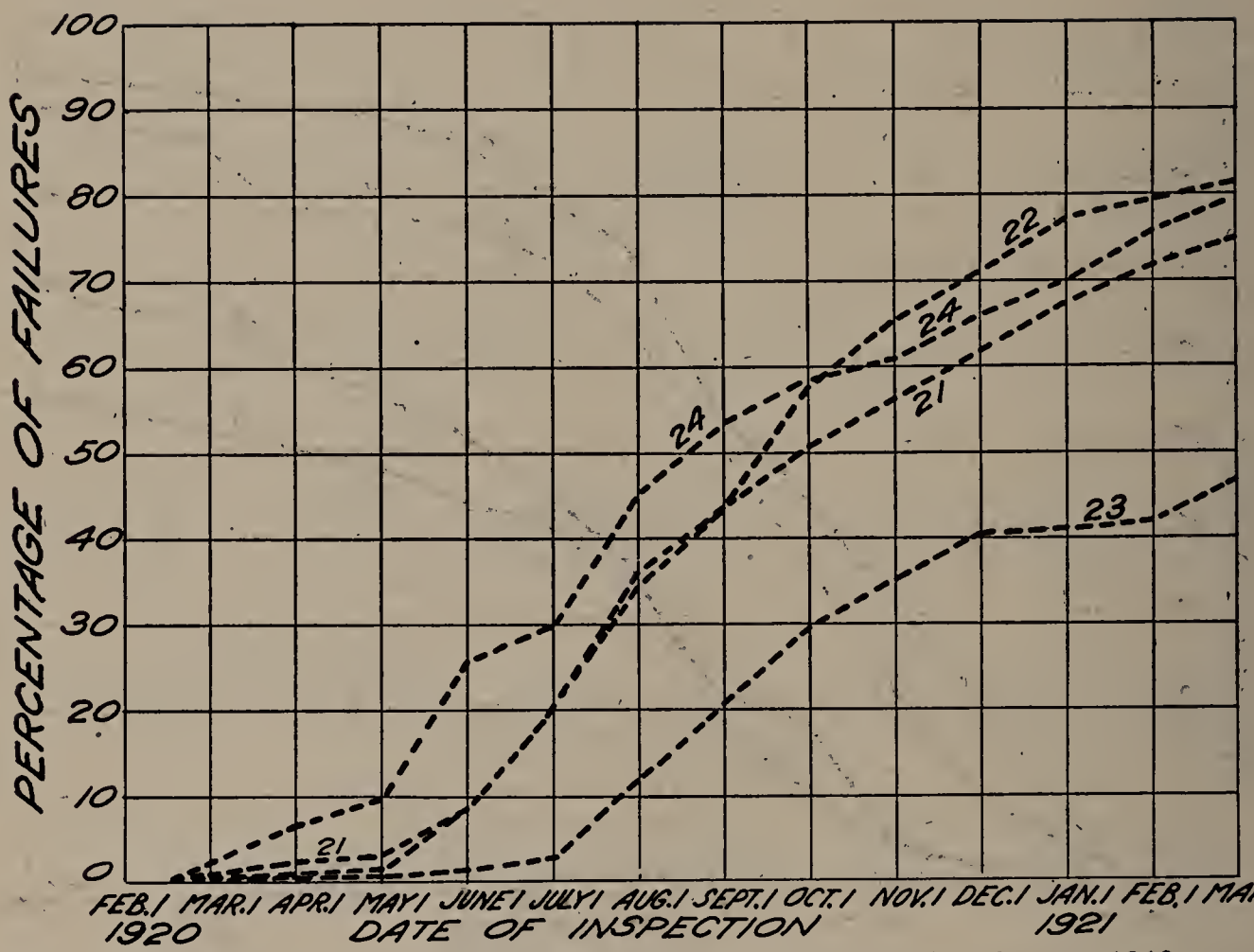


FIG. 119.—Comparison of the four copper-bearing regular heats, 1919 experimental plate; average of all products in enameled cans (Table 119).

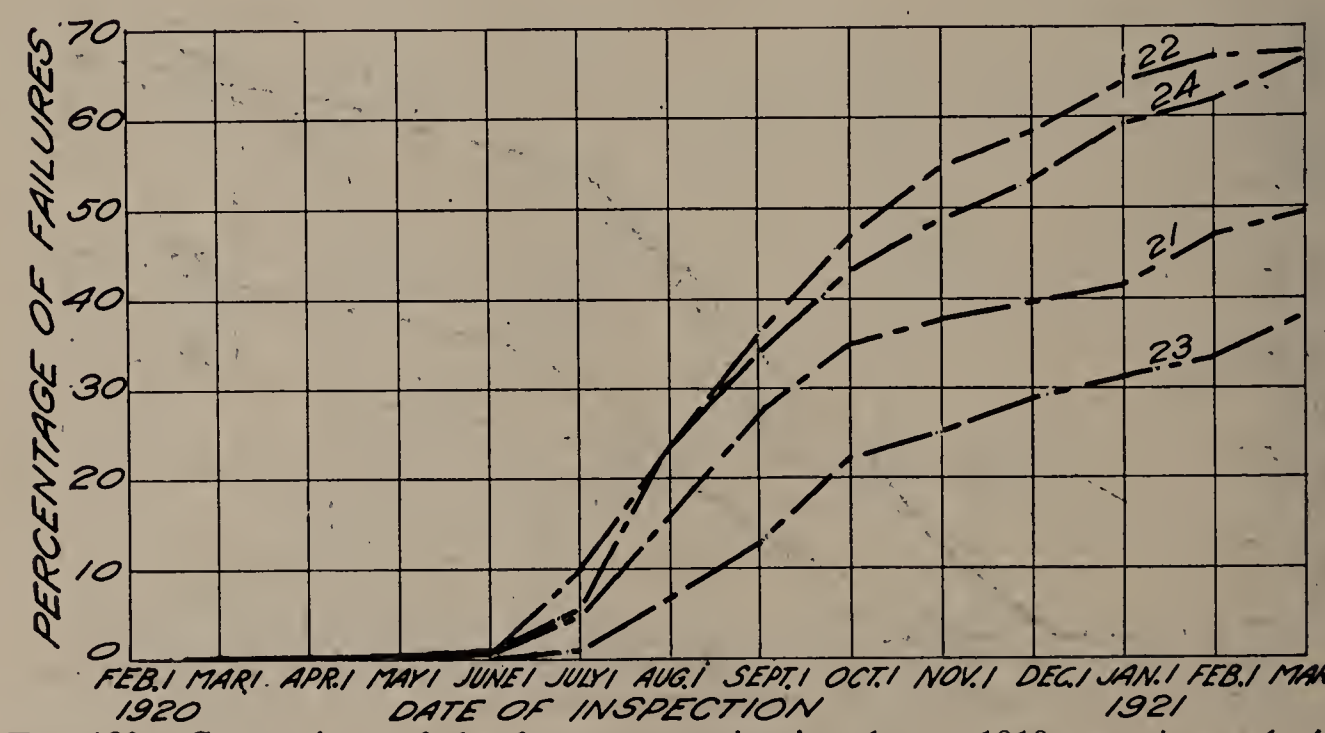


FIG. 120.—Comparison of the four copper-titanium heats, 1919 experimental plate; average of all products in enameled cans (Table 119).

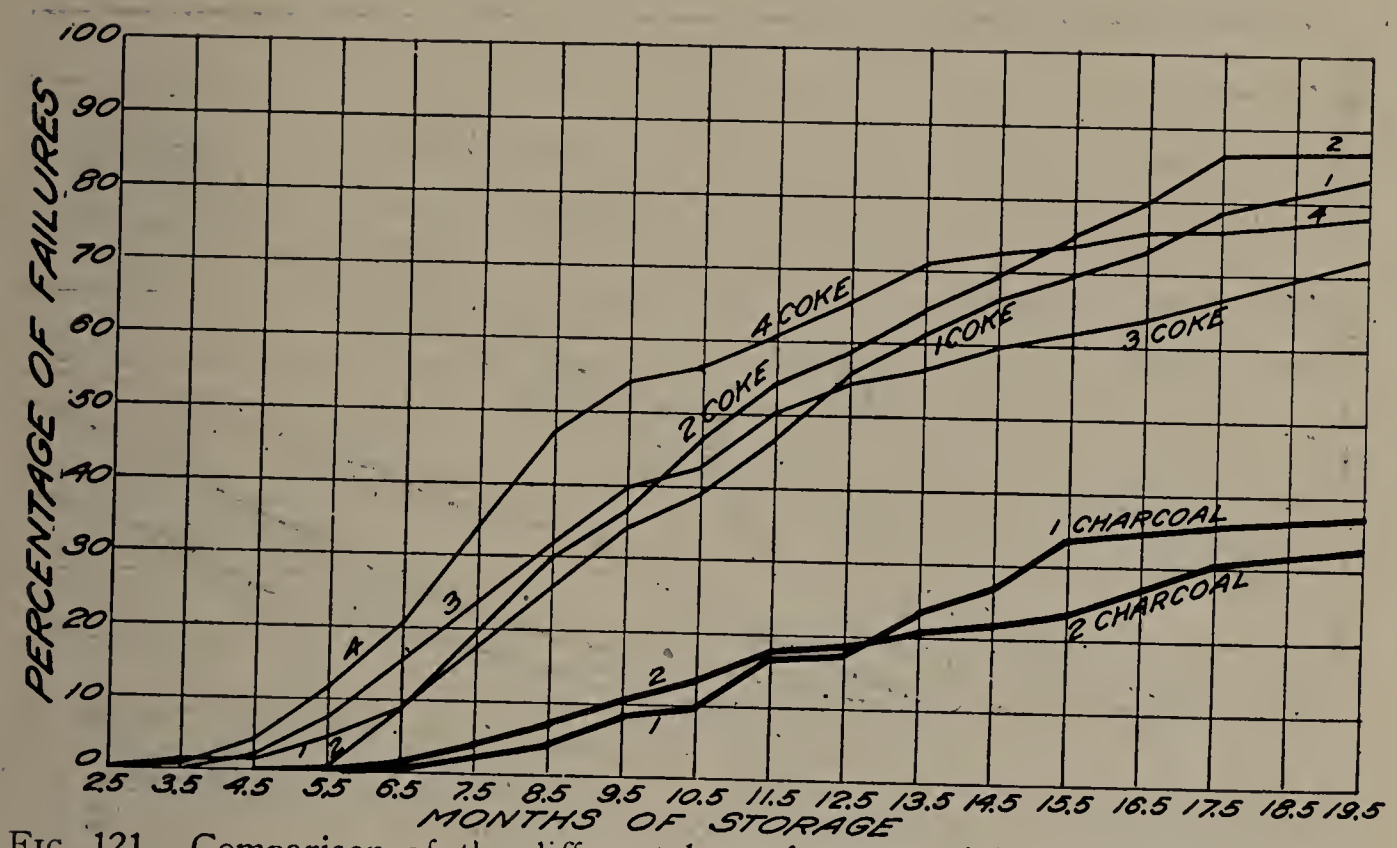


FIG. 121.—Comparison of the different lots of commercial Bessemer plate of the 1917 experiment; average of all products in enameled cans (Table 120).

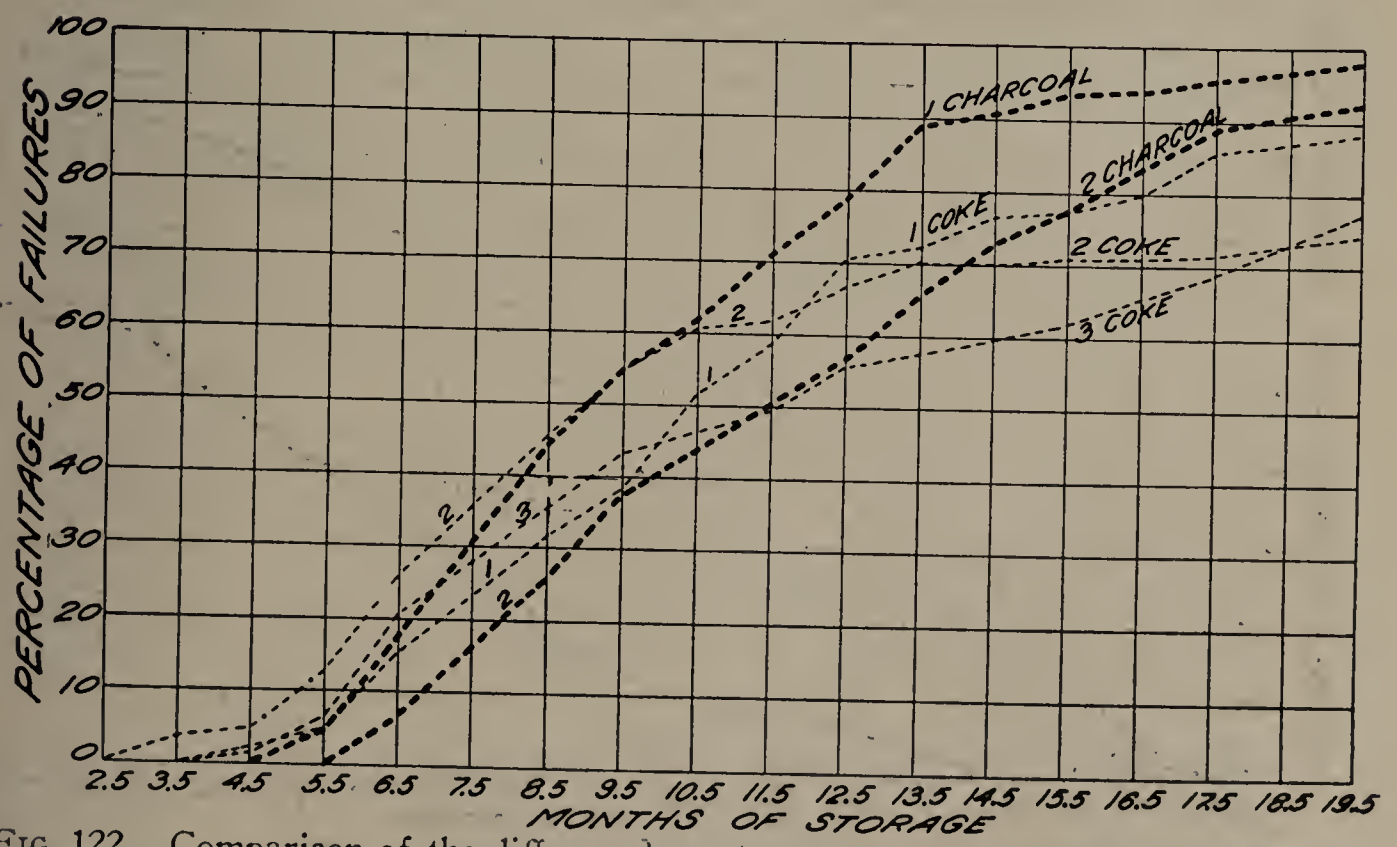


FIG. 122.—Comparison of the different lots of commercial copper-bearing Bessemer plate of the 1917 experiment; average of all products in enameled cans (Table 120).

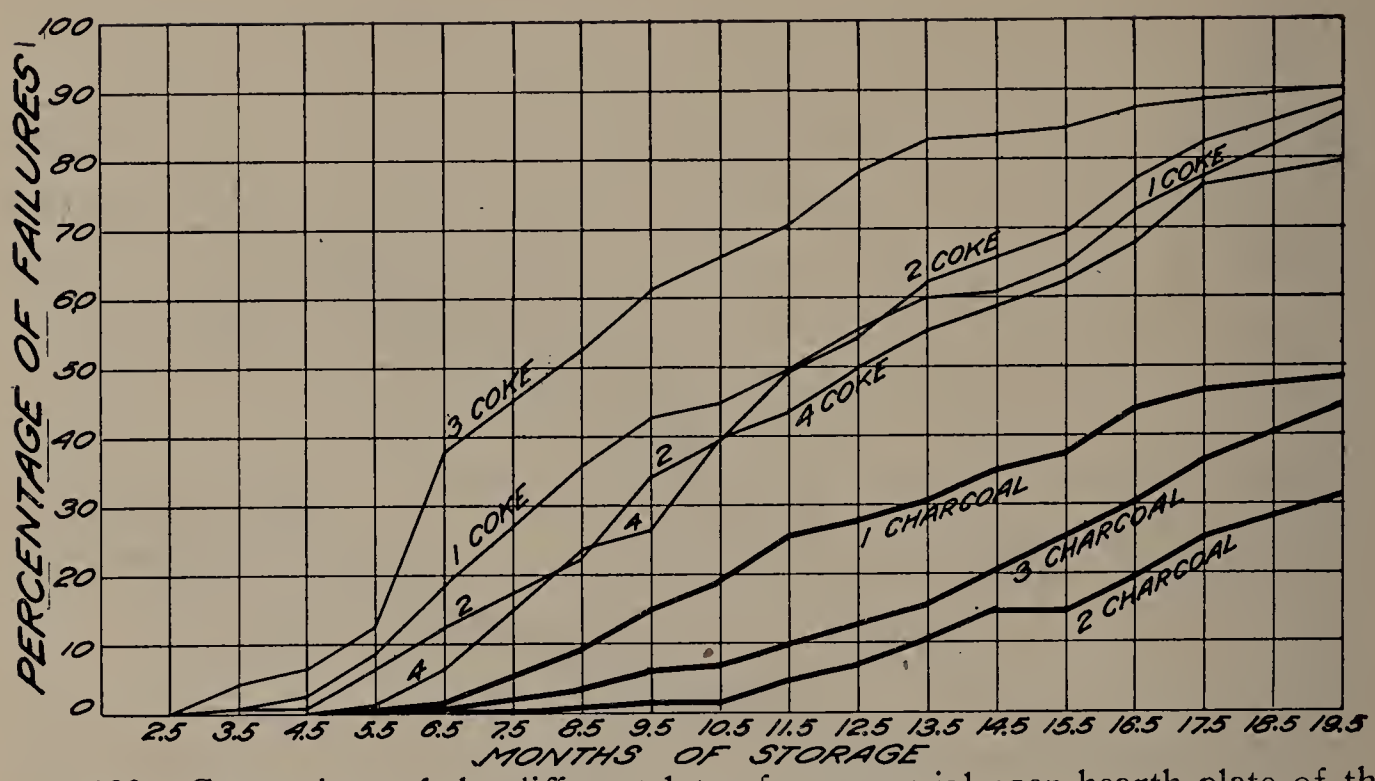


FIG. 123.—Comparison of the different lots of commercial open-hearth plate of the 1917 experiment; average of all products in enameled cans (Table 120).

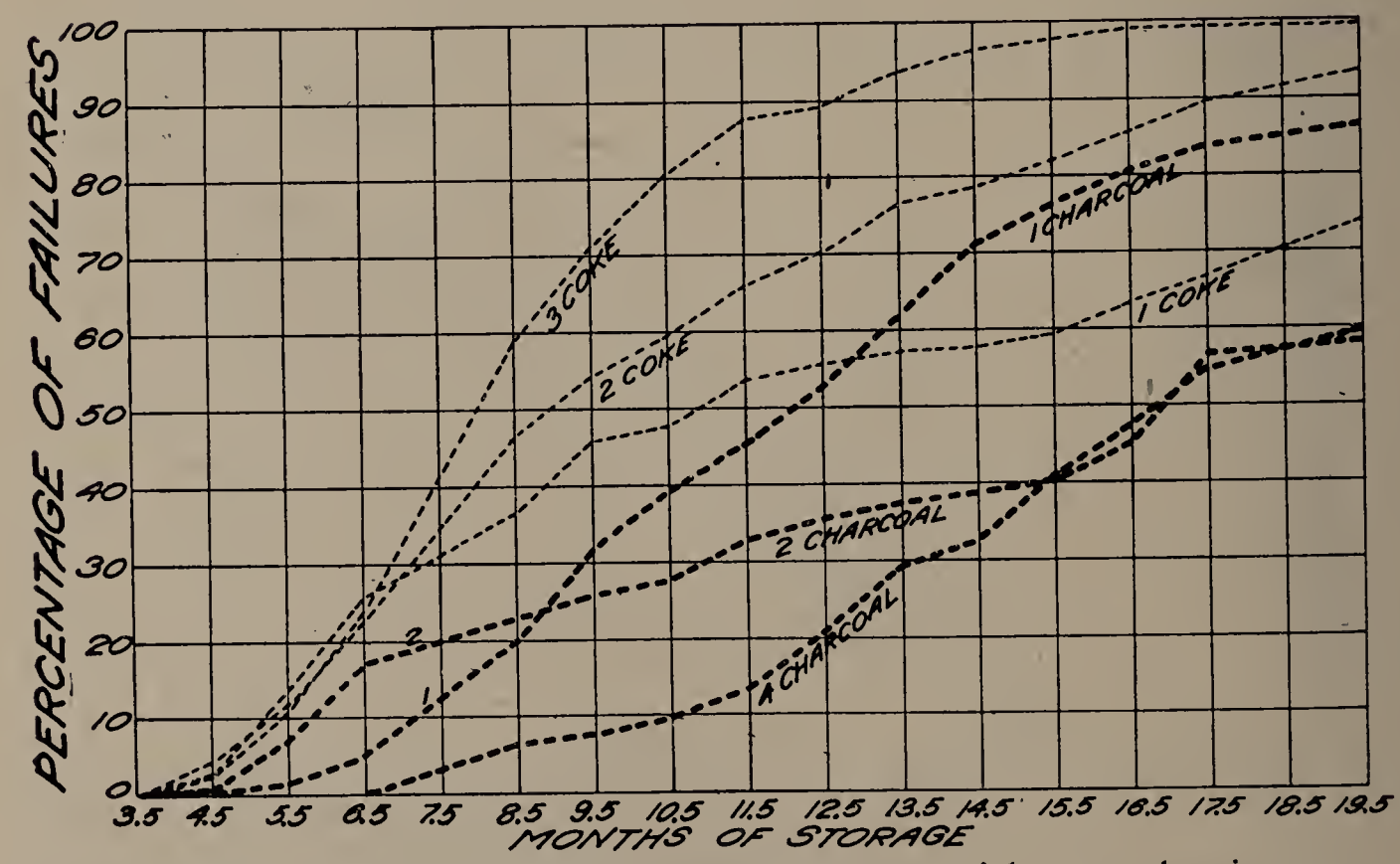


FIG. 124.—Comparison of the different lots of commercial copper-bearing open-hearth plate of the 1917 experiment; average of all products in enameled cans (Table 120).

INSPECTION OF OTHER PRODUCTS

CORN

The corn packed in Maine in 1918 was inspected in December of the same year, about three months after packing. Examination showed that discoloration appeared both on the cans and in the contents irrespective of the character of steel base or of the weight of coating on the plate. Commercially objectionable discoloration appeared in the corn packed in all lots.

Repeated examinations of these cans made at later periods extending through the years 1919 and 1920 confirmed the conclusions drawn from the first examination.

Notes were taken at each opening of the discoloration appearing on individual cans and likewise as to the condition of the contents, but as no relation could be found between the individual results and the character of the base plate or weight of coating these notes are not included in the report.

PEAS

The cans of the experimental pack of peas were stored on the side. Cans were cut as soon as they arrived at Washington, and also on three subsequent occasions. In all cans the usual black discoloration occurred in the part of the cans that was uppermost immediately after processing.

No noticeable difference could be observed between the amount or character of the black in cans of the different lots of plate.

CATSUP

Catsup in plain and enameled cans of both the regular and titanium-treated plate was examined on April 29, 1919, after being packed seven months. For comparison, the contents of glass bottles filled from the same batch were examined. The appearance and taste were noted by members of the committee and by Mr. B. Mulree of the Burt Olney Canning Company. There was no appreciable difference between that in cans of the regular and that in cans of the titanium-treated plate. The appearance of all the catsup was excellent. That in the enameled cans and in the bottle did not differ in color. That from the plain cans was a little brighter in color. A slight flavor, due probably to iron, was found in the catsup from plain cans. This flavor, however, was not noticeable to some members of the committee and was only consistently

noticed by one. The difference in color and taste was more noticeable when the can was opened without shaking and the contents examined or tasted from the top of the can. The enameled cans had been slightly attacked by the acid of the catsup. By January 1, 1922, three and one-half years after packing, only two or three cans of the entire pack had perforated or become springers.

APPENDICES

APPENDIX I.—RAW MATERIALS.

The steel was made in 50-ton open-hearth furnaces, using oil for fuel. The raw products used in the two experiments were very similar.

Materials Used in the Initial Charge.

Pig iron.—Southern pig iron was used. The approximate average analysis of the material as received at the mill is: Silicon, 0.75 per cent; carbon, 3.5–4.0 per cent; phosphorus, 0.9 per cent; sulphur, 0.03 per cent; manganese, 0.30 per cent.

Cast scrap.—This is largely borings from castings and is purchased from various sources. It may contain silicon, 2.0–3.0 per cent; sulphur, up to 0.10 per cent; phosphorus, 0.6 per cent.

Mold scrap.—Molds which crack and become useless are charged in the furnace. A typical analysis is silicon, 1.41 per cent; sulphur, 0.064 per cent; phosphorus, 0.128 per cent; manganese, 0.59 per cent.

Miscellaneous scrap.—The material charged under this heading is truly miscellaneous. It might be termed junk, being made up of all sorts of pieces of almost all kinds of articles of iron or steel. Not even approximate values for analytical figures can be guessed.

Turnings.—Turnings resulting from machining of steel.

Bundles.—Bundled shearings from sheets rolled at the mill and used elsewhere, the trimmings being bundled and returned.

Sheet mill scrap.—Shearings from the sheet mill at the plant.

Pit scrap.—Material dropped from ladle and on the outside of moulds in pouring. About the same as the steel made.

Universal mill scrap.—Crops and defective bars sheared after the ingots are rolled on the universal mill.

Raw lime.—Obtained nearby.

Burnt lime.—Obtained nearby. Analysis of a single sample: Silicon dioxide, 0.35 per cent; iron and aluminum oxides, 0.30 per cent; calcium oxide, 99.03 per cent; magnesium oxide, 0.32 per cent.

Materials Added to Furnace.

Ore.—Bates ore. Lake Superior. An average analysis: Silicon dioxide, 7.60 per cent; aluminum oxide, 3.52 per cent; ferric oxide, 80.80 per cent; phosphorus pentoxide, 0.78 per cent; manganese, 0.50 per cent; loss on ignition, 7.45 per cent. No calcium or magnesium.

Spar.—Fluorspar from Southern Illinois. An average analysis: Silicon dioxide, 2.00 per cent; iron and aluminum oxides, 0.50 per cent; calcium flouride, 98.85 per cent; magnesium oxide, trace.

Silicon pig.—Jackson County silvers from Jackson, Ohio: Silicon, 10 per cent; carbon, 1.25 per cent; sulphur, 0.025 per cent.

Ferro-manganese.—Imported. Typical analysis: Silicon, 0.49 per cent; carbon, 6.96 per cent; phosphorus, 0.160 per cent; manganese, 79.98 per cent.

Pig iron.—Described above.

Materials Added to Ladle.

Fifty per cent silicon.—An electric furnace product supposed to carry 50 per cent silicon.

Ferro-phosphorus.—Ferro-phosphorus from a furnace located in Tennessee. Typical analytical values: Silicon, 0.40 per cent; phosphorus, 18 per cent.

Ferro-manganese.—Described above.

Titanium.—Ferro-carbon-titanium, furnished by the Titanium Alloy Manufacturing Company. An average analysis is stated to be: Silicon, 1.41 per cent; titanium, 15.79 per cent; carbon, 7.46 per cent; manganese, 0.11 per cent; aluminum, 0.80 per cent; phosphorus, 0.05 per cent; sulphur, 0.08 per cent.

APPENDIX II.—OPEN-HEARTH FURNACE DATA.

TABLE 51.—TIME REQUIRED FOR HEAT, AND KIND AND QUANTITY OF MATERIALS IN FURNACE CHARGE AND FURNACE ADDITIONS, 1917 AND 1919 EXPERIMENTS.

Heat.	No.	Furnace No.	Time required for—			Total time of heat.	Furnace charge.										Furnace additions.					
			Charging.	Melting.	Working.		Pig iron.	Cast scrap.	Miscellaneous scrap.	Turnings.	Bundles.	Sheet mill scrap.	Universal and plate mill scrap.	Pit scrap.	Total metal charge.	Burnt lime.	Iron ore.	Fluorspar.	Extra pig iron.	Silicon pig.	Ferromanganese.	Spiegel.
1917 experiment.			*H. M.*	*H. M.*	*H. M.*	*H. M.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
R1	3041	2	4 55	3 55	2 29	11 19	47,800	.....	40,500	25,100	12,900	.....	15,100	.....	141,400	7,000	4,300	400	1,000	500	700	.....
R2	3070	4	4 45	4 48	2 10	11 43	48,800	3,200	46,500	33,200	.....	.....	8,800	.....	140,300	7,200	4,640	270	500	500	700	.....
R3	3069	2	5 0	4 29	1 16	10 45	35,800	11,200	49,300	42,800	.....	.....	.....	.....	139,100	6,800	.....	300	.....	500	700	.....
R4	3086	2	4 50	3 55	2 31	11 16	47,800	.....	13,600	39,400	13,800	.....	24,700	.....	139,300	6,900	2,000	540	.....	500	700	.....
R5	3032	2	4 15	3 57	1 47	9 59	43,500	6,000	33,900	23,700	15,800	.....	.....	20,800	142,500	7,400	1,200	415	.....	500	700	.....
R6	3080	5	6 15	7 45	1 42	15 42	56,000	.....	27,500	57,500	.....	.....	.....	.....	141,000	6,800	.....	680	1,500	500	700	.....
R7	3092	4	5 40	5 13	2 38	13 31	55,900	4,300	3,900	27,200	.....	21,800	.....	27,400	140,500	[a] 9,700	.....	635	8,500	500	800	.....
T1	3040	5	5 55	4 59	1 51	12 45	52,000	.....	42,300	21,900	18,400	6,900	.....	.....	141,500	7,400	1,700	515	1,000	500	700	.....
T2	3050	2	5 50	3 42	1 41	11 13	49,000	.....	43,200	46,000	.....	.....	2,800	.....	141,000	6,800	1,450	300	.....	500	600	.....
T3	3067	3	4 55	6 3	2 21	13 19	36,900	11,500	35,600	28,600	.....	7,800	.....	.....	122,400	7,300	600	404	.....	500	700	.....
T4	3085	5	6 5	5 55	2 30	14 30	56,300	.....	.....	33,600	.....	12,300	39,300	.....	141,500	6,500	3,400	560	.....	500	700	.....
T5	3033	4	4 45	4 21	1 18	10 24	51,700	.....	42,600	30,000	.....	16,500	.....	.....	139,800	7,000	1,300	400	.....	500	700	.....
T6	3076	2	5 5	4 21	1 52	11 18	47,400	.....	52,200	29,400	12,000	.....	.....	.....	141,000	6,400	1,400	340	.....	500	700	.....
T7	3090	2	3 45	5 39	1 53	11 17	59,400	.....	31,500	.....	.....	23,200	26,500	.....	140,700	[a] 9,700	1,240	490	.....	500	700	.....
1919 experiment.																						
21	4152	9	.....	.....	1 30	.....	41,500	10,600	23,100	.....	.....	56,300	.....	9,800	141,300	6,900	1,200	300	.....	500	.....	500
22	4157	9	.....	.....	2 0	.....	41,300	9,700	76,000	.....	.....	.....	.....	13,000	141,000	6,900	1,200	600	.....	250	.....	500
23	4161	9	.....	.....	2 21	.....	45,500	6,900	39,600	.....	.....	.....	49,500	.....	141,500	7,000	1,700	400	.....	500	.....	500
24	4166	9	.....	.....	2 14	.....	53,800	.....	3,100	.....	.....	31,900	27,000	24,100	139,900	5,700	3,000	600	.....	600	.....	500

[a] Limestone used instead of burnt lime.

TABLE 52.—RECORD OF ADDITIONS AND TESTS, OPEN-HEARTH FURNACE OPERATION, 1917 EXPERIMENT REGULAR HEATS.

Heat and time before tapping.	Additions and tests.
Heat R1.	
Time before tapping—	
2 hours 29 minutes	Test, carbon, 0.50%.
2 hours 24 minutes	Added 1,100 pounds ore.
2 hours 8 minutes	Test, carbon, 0.50%.
2 hours 2 minutes	Added 700 pounds ore.
1 hour 45 minutes	Test, carbon, 0.40%.
1 hour 41 minutes	Added 500 pounds ore.
1 hour 33 minutes	Test, carbon, 0.30%.
1 hour 30 minutes	Added 500 pounds ore.
1 hour 23 minutes	Added 500 pounds ore.
1 hour 13 minutes	Test, carbon, 0.20%.
1 hour 7 minutes	Added 500 pounds ore.
1 hour	Added 500 pounds ore.
53 minutes	Test, carbon, 0.16%.
50 minutes	Added 250 pounds spar.
39 minutes	Test, carbon, 0.12%; phosphorus, 0.025%.
34 minutes	Added 1,000 pounds pig iron.
33 minutes	Added 100 pounds spar.
31 minutes	Added 500 pounds silicon pig.
24 minutes	Added 50 pounds spar.
9 minutes	Test, carbon, 0.12%.
4 minutes	Added 700 pounds ferro-manganese.
Heat R2.	
Time before tapping—	
2 hours 10 minutes	Test, carbon, 0.55%.
2 hours 3 minutes	Added 860 pounds ore.
1 hour 40 minutes	Test, carbon, 0.50%.
1 hour 36 minutes	Added 1,260 pounds ore.
1 hour 13 minutes	Test, carbon, 0.40%.
1 hour 10 minutes	Added 1,470 pounds ore.
51 minutes	Test, carbon, 0.25%.
48 minutes	Added 1,050 pounds ore.
31 minutes	Test, carbon, 0.12%; phosphorus 0.075%.
27 minutes	Added 145 pounds spar.
18 minutes	Test, carbon, 0.13%.
16 minutes	Added 125 pounds spar.
14 minutes	Added 500 pounds silicon pig.
8 minutes	Added 500 pounds pig iron.
1 minute	Added 700 pounds ferro-manganese.
Heat R3.	
Time before tapping—	
1 hour 16 minutes	Test, carbon, 0.30%.
1 hour 11 minutes	Added 150 pounds spar.
45 minutes	Added 100 pounds spar.
38 minutes	Test, carbon, 0.17%; phosphorus, 0.010%.
33 minutes	Added 50 pounds spar.
20 minutes	Test, carbon, 0.15%.
18 minutes	Added 500 pounds silicon pig.
4 minutes	Added 700 pounds ferro-manganese.
Heat R4.	
Time before tapping—	
2 hours 16 minutes	Added 600 pounds ore.
1 hour 48 minutes	Added 600 pounds ore.
1 hour 26 minutes	Added 600 pounds ore.
1 hour 3 minutes	Added 200 pounds spar.
55 minutes	Test, carbon, 0.21%; phosphorus 0.015%.
50 minutes	Added 160 pounds spar.
36 minutes	Added 120 pounds spar.
32 minutes	Added 200 pounds ore.
26 minutes	Added 60 pounds spar.
21 minutes	Test, carbon, 0.16%; phosphorus, 0.015%.
16 minutes	Added 500 pounds silicon pig..
3 minutes	Added 700 pounds ferro-manganese.

TABLE 52.—RECORD OF ADDITIONS AND TESTS, OPEN-HEARTH FURNACE OPERATION, 1917 EXPERIMENT. *Continued.*

REGULAR HEATS.—*Continued.*

Heat and time before tapping.	Additions and tests.
Heat R5.	
Time before tapping—	
1 hour 47 minutes	Test, carbon, 0.40%.
1 hour 39 minutes	Added 700 pounds ore.
1 hour 19 minutes	Test, carbon, 0.30%.
1 hour 16 minutes	Added 105 pounds spar.
1 hour 9 minutes	Test, carbon, 0.21%.
1 hour 5 minutes	Added 500 pounds ore.
57 minutes	Added 210 pounds spar.
44 minutes	Test, carbon, 0.14%; phosphorus, 0.010%.
39 minutes	Added 100 pounds spar.
32 minutes	Test, carbon, 0.12%.
28 minutes	Added 500 pounds silicon pig.
9 minutes	Test, carbon, 0.10%.
4 minutes	Added 700 pounds ferro-manganese.
Heat R6.	
Time before tapping—	
1 hour 42 minutes	Test, carbon, 0.25%.
1 hour 19 minutes	Test, carbon, 0.12%.
1 hour 15 minutes	Added 1,500 pounds pig iron.
1 hour 10 minutes	Added 420 pounds spar.
52 minutes	Test, carbon, 0.17%.
48 minutes	Added 170 pounds spar.
36 minutes	Test, carbon, 0.16%.
33 minutes	Added 90 pounds spar.
24 minutes	Test, carbon, 0.13%; phosphorus, 0.070%.
20 minutes	Added 500 pounds silicon pig.
6 minutes	Test, carbon, 0.12%.
3 minutes	Added 700 pounds ferro-manganese.
Heat R7.	
Time before tapping—	
2 hours 38 minutes	Test, carbon, 0.12%.
2 hours 29 minutes	Added 135 pounds spar.
2 hours 26 minutes	Added 2,500 pounds pig iron.
2 hours 7 minutes	Added 3,500 pounds pig iron.
1 hour 47 minutes	Added 180 pounds spar.
1 hour 17 minutes	Test, carbon, 0.10%.
1 hour 1 minute	Test, carbon, 0.10%.
1 hour	Added 135 pounds spar.
53 minutes	Added 2,500 pounds pig iron.
42 minutes	Added 45 pounds spar.
30 minutes	Test, carbon, 0.08%; phosphorus, 0.005%.
24 minutes	Added 140 pounds spar.
23 minutes	Added 500 pounds silicon pig.
3 minutes	Added 800 pounds ferro-manganese.
TITANIUM-TREATED HEATS.	
Heat T1.	
Time before tapping—	
1 hour 51 minutes	Test, carbon, 0.50%.
1 hour 48 minutes	Added 1,000 pounds ore.
1 hour 23 minutes	Test, carbon, 0.35%.
1 hour 20 minutes	Added 700 pounds ore.
1 hour	Test, carbon, 0.20%.
57 minutes	Added 200 pounds spar.
50 minutes	Test, carbon, 0.13%; phosphorus, 0.040%.
45 minutes	Added 250 pounds spar.
38 minutes	Test, carbon, 0.13%.
33 minutes	Added 65 pounds spar.
31 minutes	Added 500 pounds silicon pig.
15 minutes	Test, carbon, 0.11%.
10 minutes	Added 1,000 pounds pig iron.
4 minutes	Added 700 pounds ferro-manganese.

TABLE 52.—RECORD OF ADDITIONS AND TESTS, OPEN-HEARTH FURNACE OPERATION, 1917 EXPERIMENT. *Continued.*

TITANIUM-TREATED HEATS.—*Continued.*

Heat and time before tapping.	Additions and tests.
Heat T2.	
Time before tapping—	
1 hour 41 minutes	Test, carbon, 0.40%.
1 hour 30 minutes	Added 180 pounds spar.
1 hour 19 minutes	Test, carbon, 0.30%.
1 hour 15 minutes	Added 1,450 pounds ore.
58 minutes	Test, carbon, 0.13%; phosphorus, 0.020%.
55 minutes	Added 120 pounds spar.
41 minutes	Test, carbon, 0.12%.
28 minutes	Test, carbon, 0.10%.
26 minutes	Added 500 pounds silicon pig.
6 minutes	Test, carbon, 0.09%.
3 minutes	Added 600 pounds ferro-manganese.
Heat T3.	
Time before tapping—	
2 hours 21 minutes	Test, carbon, 0.50%.
2 hours 15 minutes	Added 300 pounds ore.
1 hour 58 minutes	Test, carbon, 0.40%.
1 hour 55 minutes	Added 200 pounds spar.
1 hour 44 minutes	Test, carbon, 0.40%.
1 hour 40 minutes	Added 300 pounds ore.
1 hour 20 minutes	Test, carbon, 0.16%.
1 hour 10 minutes	Added 204 pounds spar.
54 minutes	Test, carbon, 0.12%; phosphorus, 0.005%.
33 minutes	Test, carbon, 0.09%.
31 minutes	Added 500 pounds silicon pig.
4 minutes	Added 700 pounds ferro-manganese.
Heat T4.	
Time before tapping—	
2 hours 30 minutes	Test, carbon, 0.80%.
2 hours 25 minutes	Added 1,000 pounds ore.
2 hours 10 minutes	Test, carbon, 0.60%.
2 hours 6 minutes	Added 800 pounds ore.
1 hour 54 minutes	Test, carbon, 0.50%.
1 hour 50 minutes	Added 1,000 pounds ore.
1 hour 34 minutes	Test, carbon, 0.30%.
1 hour 31 minutes	Added 400 pounds ore.
1 hour 18 minutes	Added 290 pounds spar.
1 hour 1 minute	Test, carbon, 0.18%; phosphorus, 0.030%.
51 minutes	Added 210 pounds spar.
37 minutes	Added 200 pounds ore.
35 minutes	Added 60 pounds spar.
29 minutes	Test, phosphorus, 0.015%.
13 minutes	Added 500 pounds silicon pig.
5 minutes	Added 700 pounds ferro-manganese.
Heat T5.	
Time before tapping—	
1 hour 18 minutes	Test, carbon, 0.45%.
1 hour 14 minutes	Added 1,000 pounds ore.
56 minutes	Test, carbon, 0.25%.
52 minutes	Added 225 pounds spar.
47 minutes	Test, carbon, 0.18%.
42 minutes	Added 300 pounds ore.
34 minutes	Test, carbon, 0.16%.
31 minutes	Added 175 pounds spar.
24 minutes	Test, carbon, 0.16%; phosphorus, 0.050%.
22 minutes	Added 500 pounds silicon pig.
4 minutes	Added 700 pounds ferro-manganese.
Heat T6.	
Time before tapping—	
1 hour 52 minutes	Test, carbon, 0.60%.
1 hour 46 minutes	Added 600 pounds ore.
1 hour 33 minutes	Test, carbon, 0.50%.
1 hour 29 minutes	Added 600 pounds ore.
1 hour 17 minutes	Test, carbon, 0.25%.
1 hour 13 minutes	Added 200 pounds ore.
1 hour 9 minutes	Added 150 pounds spar.
58 minutes	Test, carbon, 0.17%.
55 minutes	Added 100 pounds spar.
45 minutes	Test, carbon, 0.16%; phosphorus, 0.015%.
30 minutes	Added 90 pounds spar.
20 minutes	Test, carbon, 0.13%.
17 minutes	Added 500 pounds silicon pig.
8 minutes	Test, carbon, 0.11%.
2 minutes	Added 700 pounds ferro-manganese.

TABLE 52.—RECORD OF ADDITIONS AND TESTS, OPEN-HEARTH FURNACE OPERATION, 1917 EXPERIMENT *Continued.*

TITANIUM-TREATED HEATS.—*Continued.*

Heat and time before tapping.	Additions and tests.
Heat T7.	
Time before tapping—	
1 hour 53 minutes	Test, carbon, 0.50%.
1 hour 42 minutes	Added 1,240 pounds ore.
1 hour 18 minutes	Test, carbon, 0.16%.
1 hour 9 minutes	Added 280 pounds spar.
52 minutes	Test, carbon, 0.12%.
47 minutes	Added 160 pounds spar.
37 minutes	Test, carbon, 0.12%; phosphorus 0.010%.
31 minutes	Added 50 pounds spar.
22 minutes	Test, carbon, 0.09%.
19 minutes	Added 500 pounds silicon pig.
11 minutes	Test, carbon, 0.11%.
5 minutes	Added 700 pounds ferro-manganese.

TABLE 53.—RECORD OF ADDITIONS AND TESTS, OPEN-HEARTH FURNACE OPERATION, 1919 EXPERIMENT.

Heat 21.	
Time before tapping—	
1 hour 30 minutes	Added 700 pounds ore.
1 hour 8 minutes	Added 500 pounds ore.
42 minutes	Slag temperature, 2,840° F.
31 minutes	Slag temperature, 2,795° F.
25 minutes	Steel and slag tests taken.
19 minutes	Added 500 pounds silicon pig.
4 minutes	Slag temperature, 2,840° F.
3 minutes	Added 500 pounds spiegel
Heat 22.	
Time before tapping—	
2 hours	Added 600 pounds ore.
1 hour 6 minutes	Added 600 pounds ore.
45 minutes	Added 600 pounds spar.
26 minutes	Steel and slag tests taken.
24 minutes	Added 250 pounds silicon pig.
14 minutes	Slag temperature, 3,075° F.
8 minutes	Added 500 pounds spiegel.
Heat 23.	
Time before tapping—	
2 hours 21 minutes	Added 600 pounds ore.
1 hour 51 minutes	Added 900 pounds ore.
54 minutes	Added 400 pounds spar.
46 minutes	Added 200 pounds ore.
25 minutes	Steel and slag tests taken.
21 minutes	Added 500 pounds silicon pig.
21 minutes	Slag temperature, 2,890° F.
3 minutes	Added 500 pounds spiegel.
Heat 24.	
Time before tapping—	
2 hours 14 minutes	Added 900 pounds ore.
1 hour 47 minutes	Added 900 pounds ore.
1 hour 15 minutes	Added 900 pounds ore.
49 minutes	Added 300 pounds ore.
33 minutes	Added 600 pounds spar.
29 minutes	Steel and slag tests taken.
28 minutes	Added 600 pounds silicon pig.
19 minutes	Slag temperature, 2,920° F.
4 minutes	Added 500 pounds spiegel.

TABLE 54.—KIND AND QUANTITY OF

Heat.	Ladle additions.				Furnace tapped.		Time after tapp			
	50% ferro-silicon.	18% ferro-phos-phorus.	80% ferro-manga-nese.	Ferro-carbon-titan-ium.	Date.	Time.	Silicon, man-ganese and phosphorus additions.	Ferro-carbon-titanium. additions.	Slag came.	Ladle moved from furnace.
1917 experi-ments.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*			*Min.*	*Min.*	*Min.*	*Min.*
R1.....	12	500	.....	.....	6/1/17	2:29 P. M.	1	.....	3½	7
R2.....	12	150	.....	.....	6/4/17	7:23 P. M.	1	.....	.....	5
R3.....	12	550	.....	.....	6/4/17	2:25 P. M.	1	.....	2	5
R4.....	12	550	.....	.....	6/6/17	2:46 P. M.	1	.....	3	7
R5.....	12	600	.....	.....	5/31/17	12:09 P. M.	1	.....	2	5
R6.....	12	.....	.....	.....	6/5/17	10:12 P. M.	½	.....	2	4
R7.....	12	500	.....	.....	6/7/17	7:21 A. M.	1	.....	.....	5
T1.....	12	300	.....	165	6/1/17	12:35 P. M.	1	2	3	6
T2.....	12	500	100	165	6/2/17	12:48 P. M.	1	[a] 1½	2	5
T3.....	12	550	.....	150	6/4/17	11:49 A. M.	1	[a] 2	2	5
T4.....	12	550	50	200	6/6/17	1:25 P. M.	½	1¼	2	5½
T5.....	12	600	.....	165	5/31/17	3:39 P. M.	1	2	.....	5
T6.....	12	550	.....	200	6/5/17	1:38 P. M.	1	1¼	3	7
T7.....	12	600	.....	200	6/7/17	3:32 A. M.	1	1½	2	5
1919 experi-ment.										
R21....	.....	325	250	.....	6/3/19	10:20 P. M.	1	.....	3	.....
T21....	.....	325	250	75	6/3/19	10:20 P. M.	½	1½	2½	.....
R22....	.....	325	250	.....	6/4/19	9:45 A. M.	1	.....	3	.....
T22....	.....	325	250	75	6/4/19	9:45 A. M.	½	1½	2½	.....
R23....	.....	325	250	.....	6/4/19	10:46 P. M.	1	.....	2½	.....
T23....	.....	325	250	75	6/4/19	10:46 P. M.	1	2	3	.....
R24....	.....	325	250	.....	6/5/19	11:34 A. M.	1	.....	4	.....
T24....	.....	325	250	150	6/5/19	11:34 A. M.	½	1½	4	.....

[a] Slag ran into ladle before titanium was all added.

[b] Oxygen was used to clear nozzle of ladle when ingot was poured.

TABLE 55.—ANALYSES OF FINAL SLAGS FROM LADLES, 1917 EXPERIMENT.

Heat.	Silicon dioxide.	Calcium oxide.	Magnesium oxide.	Aluminum oxide.	Titanium oxide.	Manganese oxide.	Ferrous oxide.	Ferric oxide.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R1	17.1	39.3	6.3	3.01	0.49	5.22	13.19	3.56
R2	25.4	37.4	7.4	4.52	.16	4.91	8.78	2.42
R3	15.8	41.7	5.5	3.06	.33	5.06	15.40	3.69
R4	15.8	44.8	6.6	3.31	.21	4.12	11.52	1.44
R5	18.2	38.2	5.7	3.35	.33	4.55	14.54	4.64
R6	14.8	41.7	5.2	2.97	.02	4.49	16.56	6.03
R7	17.0	41.4	7.0	2.22	.02	4.18	13.48	2.94
T1	17.8	41.5	6.5	3.47	.79	5.22	11.81	3.66
T2	13.8	40.0	6.6	3.18	.66	4.29	15.40	4.34
T3	10.2	40.9	5.3	2.77	.78	4.73	18.00	8.32
T4	17.4	39.9	5.5	3.14	.66	4.44	11.23	3.68
T5	18.9	41.0	6.4	2.77	.30	4.03	10.80	2.72
T6	13.8	41.0	5.5	3.18	.33	4.03	14.83	2.77
T7	12.8	40.3	4.6	3.27	.33	4.70	14.83	5.12

NOTE.—About 5% or 6% of phosphorus pentoxide was also present in some of these slags, but it was not determined in all of them.

APPENDIX IV.—DATA ON INDIVIDUAL INGOTS.

TABLE 56.—TIME INGOTS WERE IN MOLD, TIME BETWEEN STRIPPING AND HEATING, AND TIME IN SOAKING PITS, WEIGHT OF INGOTS, AND NOTES ON ROLLING, 1917 AND 1919 EXPERIMENTS.

1917 EXPERIMENT.

Ingots.	Time. In molds.		Time. Between stripping and heating.		Time. In soaking pits.		Ingot weights.	Notes on rolling in universal mill.
	H.	*M.*	*H.*	*M.*	*H.*	*M.*	*Lbs.*	
R1	1	22		32	2	23	6,200	
CR1	.....			22	2	38	6,100	
T1	1	6		7	3	25	6,300	Rolled very well, no defects.
CT1	.....			4	3	23	6,200	Do.
R2		55	15	49	5	5	6,800	Hot enough, but shelly and cracked.
CR2	.....		15	52	4	41	6,900	Too cold, rolled scrappy.
T2		52	70	15	4	50	6,500	Too cold, a few cracks and bottom shelly; finished very cold.
CT2	.....		70	17	4	42	6,900	Too cold; little scale rolled in; a few cracks; front buckled.
R3	1	19		14	1	47	6,400	Too cold; hard to roll.
CR3	.....			19	1	47	5,900	Difficult to roll.
T3	1	23		5	1	33	5,500	Little scale on surface, and poor top.
CT3	.....			6	1	37	5,700	Rolled well.
R4	1	14		8	1	53	6,000	
T4	1			17	1	22	6,300	
R5	1	13		17	2	10	6,300	
T5	1	14		4	1	52	6,400	
R6	1	11		7	2	54	6,200	Rolled clean; not turned over.
T6	1	12		10	1	33	6,300	Do.
R7	1	7		13	1	14	5,900	Too cold and hard; scrap on edges near bottom.
T7	1	12		2	1	35	6,500	

1919 EXPERIMENT.

R21	1	30	15	5	13	10,800	Bled slightly at top when placed for rolling.
CR21	1	30	13	5	19		Same, and cracked badly at bottom when rolled.
SR21	1	30	9	5	7	12,700	Small crack at bottom end.
SCR21	1	30	9	4	57		Mill broke and ingot was reheated: scrappy near bottom.
T21	1	34	17	1	39	10,100	Rolled clean.
CT21	1	34	15	1	45		Very scrappy at bottom third; rolled only to ½ inch thickness.
ST21	1	34	10	5	7	12,900	Very small crack at bottom.
SCT21	1	34	6	2	47		Badly split bottom, but only one quarter as scrappy as CT1.
R22	2	35	47	6	41	11,700	Rolled well.
CR22	2	35	47	6	34		Do.
SR22	2	35	47	4	55	12,700	Very hard to roll.
SCR22	2	35	48	6	22		Too hard to roll; reheated but still hard.
T22	2	39	48	3	18	12,400	
CT22	2	39	48	3	23		
ST22	2	39	50	3		12,900	
SCT22	2	39	50	3	6		
R23	1	17	17	1	55	12,300	Hard to roll; badly cracked top.
CR23	1	17	15	2	1		Hard to roll; cracked near middle; scrappy and split.
SR23	1	17	13	2	20	13,200	Hard to roll; little scrap along edge at bottom and top.
SCR23	1	17	10	2	11		Little scrap on bottom half.
T23	1	21	5	1	56	12,100	Good surface.
CT23	1	21	5	1	50		Good surface and ends.

TABLE 56.—TIME INGOTS WERE IN MOLD, TIME BETWEEN STRIPPING AND HEATING, AND TIME IN SOAKING PITS, WEIGHT OF INGOTS, AND NOTES ON ROLLING, 1917 AND 1919 EXPERIMENTS.—*Continued.*

1919 EXPERIMENT.—*Continued.*

Ingots.	Time. In molds.	Time. Between stripping and heating.	Time. In soaking pits.	Ingot weights.	Notes on rolling in universal mill.
ST23	1 21	5	3 20	12,600	Rolled a little softer than others; good surface.
SCT23	1 21	5	3 13		Little scrap near top.
R24	1 13	9	3 14	12,500	Large crack on narrow side near middl .
CR24	1 13	9	3 7		No cracks; rolled very well.
SR24	1 13	11	1 17	12,700	Cracked on side at middle; bled at top; bottom cold.
SCR24	1 13	11	1 24		Cracked badly down to middle, and bled; bottom cold.
T24	1 17	6	3 2	12,200	Cracked quite badly on narrow side below middle.
CT24	1 17	6	2 55		Cracked slightly on narrow side down to middle.
ST24	1 17	8	2 40	12,600	Do.
SCT24	1 17	8	2 45		Cracked slightly on all sides, top to bottom.

TABLE 57.—APPEARANCE OF INGOTS OF 1919 EXPERIMENT WHEN STRIPPED.

Ingots.	Appearance when stripped.
CR21	Streak due to burnt mold 1 foot from top on one side.
ST21	Slight streak.
SCT21	Mold scrap on one side.
R22	Bad surface.
CR22	Bad surface 2 feet from top on one side, due to burnt mold.
R23	Mold scrap on one side.
CR23	Mark from burnt mold on one side; crack in middle.
SR23	Considerable mold scrap.
SCR23	Do.
SCT23	Mold scrap on one side near top.
T24	Bad surface defect across side of ingot near middle, due to burnt mold

TABLE 58.—WEIGHT OF FRONT CROP, OTHER SCRAP, SAMPLES, AND GOOD BARS FROM EACH INGOT OF 1917 EXPERIMENT.

Ingots.	Front crop.	Other scrap.	Samples.	Good bars.	Total weight.	Front crop.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Per cent.*
R1	143	875	129	4,600	5,747	2.49
CR1	164.5	122	130.5	5,500	5,917	2.79
T1	138	146	130.5	5,375	5,789.5	2.38
CT1	89	172	129	5,700	6,090	1.46
R2	174	201.5	131.5	4,950	5,457	3.19
CR2	140	288	130	5,200	5,758	2.43
T2	134	214	143	5,875	6,366	2.10
CT2	177	232	126	6,100	6,635	2.67
R3	190	225	131	5,250	5,796	3.28
CR3	136.5	109.5	140	5,475	5,861	2.33
T3	240	175	131	5,000	5,546	4.33
CT3	201	172	129.5	5,050	5,552.5	3.62
R4	97.5	346	130.5	5,250	5,824	1.67
T4	198	188	148	5,350	5,884	3.37
R5	119	183	128	5,220	5,650	2.11
T5	146	154	131	5,500	5,931	2.46
R6	113	450	130.5	5,150	5,843.5	1.93
T6	210	163	131	5,550	6,054	3.47
R7	235	181	118.5	5,300	5,834.5	4.03
T7	153	258	135.5	5,950	6,496.5	2.36

APPENDIX V.—CHEMICAL ANALYSES OF SHEET BARS.

TABLE 59.—CARBON, MANGANESE, PHOSPHORUS, SULPHUR, AND COPPER CONTENT OF SHEET-BAR SAMPLES, 1917 EXPERIMENT.

Regular steel.						Titanium-treated steel.					
Samples.	Carbon.	Manganese.	Phosphorus.	Sulphur.	Copper.[a]	Samples.	Carbon.	Manganese.	Phosphorus	Sulphur	Copper.[a]
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R1a Center	0.16	0.27	0.064	0.040	.....	T1a Center	0.16	0.30	0.088	0.093	.....
R1a Edge	.14	.26	.051	.029	.....	T1a Edge	.14	.29	.045	.033	.....
R1b Center	.14	.27	.061	.067	.....	T1b Center	.15	.31	.066	.055	.....
R1b Edge	.13	.26	.059	.034	.....	T1b Edge	.16	.30	.055	.045	.....
R1c Center	.14	.28	.092	.057	.....	T1c Center	.17	.30	.063	.051	.....
R1c Edge	.15	.25	.059	.031	.....	T1c Edge	.17	.29	.054	.052	.....
R1d Center	.15	.29	.065	.042	.....	T1d Center	.17	.29	.045	.037	.....
R1d Edge	.14	.26	.052	.032	.....	T1d Edge	.15	.30	.041	.032	.....
CR1a Center	.15	.27	.086	.046	.....	CT1a Center	.13	.31	.064	.049	.....
CR1a Edge	.14	.28	.057	.030	.....	CT1a Edge	.11	.29	.035	.025	.....
CR1b Center	.18	.28	.086	.059	.....	CT1b Center	.13	.31	.057	.070	.....
CR1b Edge	.15	.26	.064	.033	.....	CT1b Edge	.11	.30	.057	.057	.....
CR1c Center	.20	.28	.093	.057	.....	CT1c Center	.14	.30	.057	.047	.....
CR1c Edge	.19	.26	.067	.034	.....	CT1c Edge	.12	.29	.043	.032	.....
CR1d Center	.11	.26	.056	.031	.....	CT1d Center	.11	.30	.035	.032	.....
CR1d Edge	.13	.26	.053	.029	.....	CT1d Edge	.11	.30	.040	.031	.....
R2a Center	.22	.30	.164	.095	0.11	T2a Center	.16	.23	.095	.073	0.11
R2a Edge	.22	.31	.140	.059	.10	T2a Edge	.12	.22	.060	.035	.11
R2b Center	.22	.30	.124	.075	.10	T2b Center	.16	.21	.083	.062	.10
R2b Edge	.22	.30	.128	.069	.09	T2b Edge	.15	.21	.067	.043	.11
R2c Center	.20	.28	.126	.077	.10	T2c Center	.14	.21	.079	.056	.10
R2c Edge	.20	.28	.130	.061	.10	T2c Edge	.12	.20	.053	.028	.10
R2d Center	.16	.29	.100	.051	.08	T2d Center	.12	.18	.051	.029	.10
R2d Edge	.15	.29	.091	.046	.11	T2d Edge	.13	.18	.047	.025	.10
CR2a Center	.20	.29	.161	.100	.43	CT2a Center	.12	.25	.097	.091	.38
CR2a Edge	.22	.29	.131	.077	.46	CT2a Edge	.10	.23	.058	.038	.35
CR2b Center	.17	.31	.136	.071	.39	CT2b Center	.11	.22	.082	.057	.37
CR2b Edge	.18	.29	.116	.069	.41	CT2b Edge	.12	.23	.069	.047	.34
CR2c Center	.21	.29	.129	.071	.40	CT2c Center	.13	.22	.072	.055	.33
CR2c Edge	.20	.28	.135	.062	.39	CT2c Edge	.11	.23	.065	.049	.39
CR2d Center	.16	.29	.088	.041	.40	CT2d Center	.09	.23	.051	.031	.49
CR2d Edge	.17	.30	.091	.043	.45	CT2d Edge	.09	.23	.049	.031	.65
R3a Center	.13	.36	.113	.062	.....	T3a Center	.07	.30	.095	.054	.....
R3a Edge	.14	.33	.068	.036	.....	T3a Edge	.06	.28	.058	.028	.....
R3b Center	.16	.33	.085	.044	.....	T3b Center	.10	.29	.095	.052	.....
R3b Edge	.17	.35	.073	.033	.....	T3b Edge	.10	.31	.054	.023	.....

R3c	Center	.16	.34	.084	.046	.....
	Edge	.15	36	.070	.033	.....
R3d	Center	.16	.35	.059	.034	.....
	Edge	.18	.34	.063	.030	.....
CR3a	Center	.17	.28	.087	.044	.....
	Edge	.18	.29	.060	.028	.....
CR3b	Center	.18	.30	.079	.050	.....
	Edge	.17	.32	.079	.040	.....
CR3c	Center	.19	.31	.086	.039	.....
	Edge	.17	.32	.081	.042	.....
CR3d	Center	.18	.31	.061	.026	.....
	Edge	.17	.32	.058	.022	.....
R4a	Center	.15	.29	.105	.042	.....
	Edge	.14	.27	.065	.026	.....
R4b	Center	.14	.29	.093	.046	.....
	Edge	.15	.29	.065	.030	.....
R4c	Center	.14	.27	.090	.044	.....
	Edge	.12	.26	.069	.029	.....
R4d	Center	.12	.29	.062	.025	.....
	Edge	.11	.29	.057	.027	.....
R5a	Center	.14	.23	.095	.064	.....
	Edge	.10	.22	.055	.033	.....
R5b	Center	.11	.23	.087	.057	.....
	Edge	.12	.23	.064	.034	.....
R5c	Center	.11	.23	.052	.054	.....
	Edge	.08	.22	.060	.038	.....
R5d	Center	.11	.23	.058	.039	.....
	Edge	.11	.23	.055	.038	.....
R6a	Center	.14	.38	.104	.060	.....
	Edge	.12	.39	.085	.048	.....
R6b	Center	.16	.38	.101	.058	.....
	Edge	.14	.38	.085	.046	.....
R6c	Center	.13	.38	.099	.063	.....
	Edge	.11	.38	.076	.038	.....
R6d	Center	.12	.37	.062	.036	.....
	Edge	.12	.39	.075	.043	.....
R7a	Center	.14	.51	.104	.067	.....
	Edge	.12	.32	.063	.032	.....
R7b	Center	.13	.33	.098	.056	.....
	Edge	.11	.33	.072	.040	.....
R7c	Center	.12	.33	.092	.054	.....
	Edge	.12	.33	.070	.041	.....
R7d	Center	.11	.32	.064	.038	.....
	Edge	.10	.31	.061	.031	.....
T3c	Center	.09	.28	.096	.046	.....
	Edge	.08	.29	.058	.027	.....
T3d	Center	.09	.26	.056	.026	.....
	Edge	.08	.24	.052	.027	.....
CT3a	Center	.14	.28	.099	.056	.....
	Edge	.13	.27	.057	.022	.....
CT3b	Center	.11	.27	.088	.042	.....
	Edge	.11	.25	.057	.020	.....
CT3c	Center	.16	.27	.092	.050	.....
	Edge	.14	.24	.055	.032	.....
CT3d	Center	.11	.27	.053	.028	.....
	Edge	.12	.26	.051	.024	.....
T4a	Center	.20	.26	.122	.050	.....
	Edge	.17	.27	.109	.047	.....
T4b	Center	.17	.27	.103	.040	.....
	Edge	.16	.28	.109	.041	.....
T4c	Center	.17	.30	.101	.039	.....
	Edge	.16	.30	.095	.039	.....
T4d	Center	.19	.27	.064	.035	.....
	Edge	.19	.29	.073	.034	.....
T5a	Center	.17	.33	.115	.076	.....
	Edge	.16	.32	.095	.045	.....
T5b	Center	.19	.34	.118	.073	.....
	Edge	.14	.32	.084	.046	.....
T5c	Center	.19	.33	.123	.066	.....
	Edge	.16	.33	.106	.062	.....
T5d	Center	.16	.30	.073	.037	.....
	Edge	.14	.33	.077	.038	.....
T6a	Center	.18	.32	.131	.076	.....
	Edge	.15	.31	.066	.033	.....
T6b	Center	.14	.31	.098	.050	.....
	Edge	.12	.30	.089	.045	.....
T6c	Center	.13	.32	.096	.051	.....
	Edge	.12	.31	.074	.037	.....
T6d	Center	.11	.30	.053	.028	.....
	Edge	.11	.31	.072	.029	.....
T7a	Center	.14	.31	.116	.047	.....
	Edge	.12	.29	.077	.027	.....
T7b	Center	.11	.31	.116	.040	.....
	Edge	.09	.29	.084	.028	.....
T7c	Center	.10	.30	.100	.040	.....
	Edge	.09	.27	.068	.025	.....
T7d	Center	.10	.28	.066	.024	.....
	Edge	.10	.28	.072	.024	.....

[a] Copper determined for only R2, CR2, T2 and CT2.

TABLE 60.—CARBON, MANGANESE, PHOSPHORUS, SULPHUR, COPPER, SILICON AND TITANIUM CONTENT OF SHEET-BAR SAMPLES, 1919 EXPERIMENT.

REGULAR STEEL.

Samples.		Carbon.	Manganese.	Phosphorus.	Sulphur.	Copper.	Silicon.	Titanium.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R21c	Center.	0.10	0.30	0.064	0.046	0.040	0.008	0.0008
	Edge.	.10	.30	.063	.024	.040	.005	.0008
R21h	Center.	.10	.30	.040	.030	.048	.005	.0008
	Edge.	.10	.29	.044	.027	.055	.005	.0008
R21i	Center.	.10	.27	.048	.021	.048	.005	.0007
	Edge.	.10	.27	.049	.022	.055	.005	.0007
CR21c	Center.	.13	.28	.073	.040	.138	.009	.0008
	Edge.	.09	.30	.054	.022	.119	.009	.0008
CR21h	Center.	.11	.31	.072	.044	.135	.005	.0006
	Edge.	.09	.29	.070	.026	.123	.005	.0008
CR21i	Center.	.11	.29	.050	.025	.127	.009	.0007
	Edge.	.09	.27	.050	.023	.127	.005	.0007
SR21c	Center.	.13	.28	.064	.039	.042	.080	.0008
	Edge.	.14	.29	.065	.035	.040	.081	.0008
SR21h	Center.	.13	.29	.066	.039	.052	.085	.0008
	Edge.	.14	.30	.064	.047	.052	.099	.0006
SR21i	Center.	.12	.28	.060	.029	.048	.061	.0009
	Edge.	.14	.30	.062	.027	.048	.071	.0007
R22c	Center.	.16	.40	.044	.080	.083	.005	.0010
	Edge.	.17	.38	.036	.056	.068	.009	.0010
R22h	Center.	.12	.38	.104	.051	.067	.009	.0008
	Edge.	.14	.37	.096	.025	.067	.019	.0008
R22i	Center.	.09	.37	.069	.033	.062	.009	.0008
	Edge.	.10	.38	.062	.037	.063	.007	.0008
CR22c	Center.	.20	.41	.135	.074	.287	.009	.0006
	Edge.	.21	.41	.110	.065	.287	.009	.0004
CR22h	Center.	.14	.37	.092	.048	.271	.009	.0007
	Edge.	.13	.36	.105	.051	.274	.009	.0008
CR22i	Center.	.12	.37	.063	.031	.306	.005	.0010
	Edge.	.11	.37	.071	.035	.339	.005	.0010
SR22c	Center.	.12	.39	.093	.049	.063	.089	.0008
	Edge.	.14	.39	.104	.055	.063	.075	.0007
SR22h	Center.	.18	.40	.086	.047	.060	.021	.0007
	Edge.	.15	.39	.084	.053	.060	.075	.0006
SR22i	Center.	.15	.38	.089	.045	.068	.090	.0010
	Edge.	.13	.38	.089	.042	.063	.090	.0012
R23c	Center.	.13	.34	.099	.073	.063	.009	.0006
	Edge.	.13	.32	.066	.038	.062	.009	.0008
R23h	Center.	.13	.33	.079	.054	.068	.019	.0008
	Edge.	.10	.33	.062	.032	.065	.009	.0007
R23i	Center.	.08	.31	.051	.030	.055	.009	.0009
	Edge.	.09	.31	.053	.030	.060	.005	.0009
CR23c	Center.	.14	.34	.089	.067	.288	.009	.0007
	Edge.	.11	.30	.066	.035	.277	.009	.0007
CR23h	Center.	.13	.36	.058	.033	.287	.009	.0007
	Edge.	.11	.31	.084	.053	.287	.005	.0008
CR23i	Center.	.11	.31	.048	.033	.284	.005	.0007
	Edge.	.09	.30	.049	.035	.279	.009	.0007
SR23c	Center.	.12	.32	.079	.045	.072	.075	.0008
	Edge.	.16	.31	.063	.050	.065	.075	.0008
SR23h	Center.	.14	.32	.059	.040	.060	.078	.0009
	Edge.	.14	.32	.056	.045	.059	.078	.0007
SR23i	Center.	.09	.30	.052	.028	.063	.024	.0006
	Edge.	.19	.30	.054	.039	.063	.036	.0007
R24c	Center.	.20	.32	.177	.103	.051	.005	.0008
	Edge.	.19	.32	.132	.072	.051	.005	.0008
R24h	Center.	.18	.32	.120	.057	.043	.005	.0005
	Edge.	.15	.31	.098	.052	.040	.005	.0005
R24i	Center.	.11	.28	.076	.041	.064	.016	.0007
	Edge.	.13	.29	.076	.050	.052	.012	.0007
CR24c	Center.	.25	.31	.166	.113	.287	.005	.0006
	Edge.	.20	.32	.156	.081	.287	.005	.0006
CR24h	Center.	.17	.32	.104	.068	.331	.009	.0005
	Edge.	.17	.32	.115	.063	.281	.009	.0005
CR24i	Center.	.15	.30	.088	.030	.327	.005	.0006
	Edge.	.13	.31	.085	.040	.303	.009	.0006
SR24c	Center.	.19	.33	.117	.058	.039	.086	.0006
	Edge.	.20	.34	.118	.052	.039	.086	.0006
SR24h	Center.	.17	.37	.096	.056	.055	.088	.0009
	Edge.	.17	.39	.104	.061	.063	.089	.0009
SR24i	Center.	.13	.33	.094	.044	.044	.037	.0006
	Edge.	.14	.31	.093	.046	.048	.037	.0006

TABLE 60.—CARBON, MANGANESE, PHOSPHORUS, SULPHUR, COPPER, SILICON AND TITANIUM CONTENT OF SHEET-BAR SAMPLES, 1919 EXPERIMENT.—*Continued.*

TITANIUM-TREATED STEEL.

Samples.		Carbon.	Manganese.	Phosphorus.	Sulphur.	Copper.	Silicon.	Titanium.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
T21c	Center.	0.10	0.26	0.044	0.036	0.041	0.015	0.0007
	Edge.	.11	.25	.036	.025	.040	.012	.0007
T21h	Center.	.11	.29	.049	.039	.048	.004	.0007
	Edge.	.10	.27	.037	.021	.051	.005	.0007
T21i	Center.	.10	.34	.035	.023	.048	.009	.0006
	Edge.	.13	.34	.037	.024	.044	.005	.0006
CT21c	Center.	.13	.24	.056	.049	.088	.005	.0007
	Edge.	.09	.23	.038	.025	.083	.005	.0007
CT21h	Center.	.11	.26	.049	.031	.095	.023	.0007
	Edge.	.09	.26	.050	.023	.087	.019	.0007
CT21i	Center.	.13	.26	.038	.028	.090	.005	.0006
	Edge.	.11	.26	.036	.027	.090	.005	.0006
ST21c	Center.	.14	.24	.056	.040	.052	.118	.0007
	Edge.	.14	.25	.058	.036	.044	.113	.0007
ST21h	Center.	.16	.26	.048	.029	.040	.098	.0007
	Edge.	.14	.28	.049	.039	.040	.108	.0007
ST21i	Center.	.15	.15	.045	.035	.048	.071	.0008
	Edge.	.15	.24	.047	.033	.041	.061	.0008
T22c	Center.	.20	.34	.091	.074	.063	.012	.0007
	Edge.	.19	.33	.085	.059	.063	.019	.0006
T22h	Center.	.16	.30	.073	.052	.063	.005	.0009
	Edge.	.16	.30	.067	.050	.070	.005	.0009
T22i	Center.	.10	.29	.050	.039	.063	.005	.0012
	Edge.	.11	.30	.047	.033	.062	.005	.0010
CT22c	Center.	.19	.31	.084	.065	.295	.005	.0010
	Edge.	.19	.31	.070	.056	.295	.005	.0010
CT22h	Center.	.20	.31	.068	.055	.274	.009	.0009
	Edge.	.18	.31	.067	.054	.293	.011	.0012
CT22i	Center.	.13	.28	.061	.033	.359	.014	.0007
	Edge.	.13	.30	.052	.036	.382	.009	.0007
ST22c	Center.	.15	.32	.062	.048	.063	.120	.0010
	Edge.	.14	.33	.071	.054	.060	.120	.0011
ST22h	Center.	.14	.31	.062	.042	.068	.090	.0010
	Edge.	.19	.31	.062	.049	.060	.120	.0008
ST22i	Center.	.13	.31	.051	.037	.085	.051	.0009
	Edge.	.13	.30	.049	.032	.070	.023	.0007
T23c	Center.	.12	.31	.088	.071	.060	.005	.0008
	Edge.	.11	.31	.053	.034	.059	.005	.0008
T23h	Center.	.15	.30	.073	.055	.063	.009	.0009
	Edge.	.14	.30	.064	.048	.059	.009	.0006
T23i	Center.	.09	.29	.045	.030	.060	.009	.0009
	Edge.	.11	.29	.043	.029	.059	.005	.0007
CT23c	Center.	.22	.33	.111	.088	.314	.009	.0008
	Edge.	.12	.29	.058	.034	.280	.009	.0007
CT23h	Center.	.13	.31	.073	.047	.279	.009	.0009
	Edge.	.14	.29	.065	.041	.284	.009	.0009
CT23i	Center.	.10	.28	.049	.041	.199	.005	.0009
	Edge.	.10	.29	.050	.039	.271	.019	.0008
ST23c	Center.	.14	.31	.074	.044	.055	.094	.0009
	Edge.	.14	.30	.065	.045	.054	.094	.0009
ST23h	Center.	.20	.29	.076	.040	.063	.088	.0009
	Edge.	.21	.31	.061	.048	.063	.088	.0008
ST23i	Center.	.11	.30	.058	.041	.060	.070	.0008
	Edge.	.11	.30	.054	.039	.055	.042	.0008
T24c	Center.	.21	.29	.098	.060	.047	.005	.0008
	Edge.	.21	.30	.099	.072	.043	.005	.0008
T24h	Center.	.19	.36	.085	.061	.056	.009	.0009
	Edge.	.19	.35	.094	.073	.056	.005	.0009
T24i	Center.	.13	.29	.063	.034	.051	.009	.0009
	Edge.	.14	.30	.062	.036	.044	.009	.0009
CT24c	Center.	.24	.31	.100	.074	.287	.005	.0007
	Edge.	.23	.31	.106	.077	.287	.005	.0007
CT24h	Center.	.22	.35	.084	.051	.287	.005	.0009
	Edge.	.20	.34	.092	.061	.287	.009	.0009
CT24i	Center.	.14	.29	.063	.030	.298	.014	.0008
	Edge.	.15	.29	.060	.038	.287	.019	.0008
ST24c	Center.	.19	.30	.090	.040	.063	.108	.0030
	Edge.	.20	.30	.086	.057	.079	.113	.0023
ST24h	Center.	.19	.34	.084	.051	.048	.108	.0025
	Edge.	.19	.34	.083	.057	.048	.094	.0020
ST24i	Center.	.15	.29	.061	4 1	.055	.075	.0025
	Edge.	.17	.31	.087	.052	.095	.113	.0025

APPENDIX VI.—MANGANESE AND PHOSPHORUS DISTRIBUTION BETWEEN THE HALF-HEATS OF 1919 EXPERIMENT.

In the 1919 experiment, where each heat of steel was divided between two ladles, both manganese and phosphorus were found appreciably lower in the titanium-treated half of each heat than in the regular untreated half. This condition occurred in spite of the fact that in every heat the same weight of ferro-manganese and ferro-phosphorus was added to each ladle, and in two cases less titanium-treated steel than regular steel was so treated, which should have given a higher content in the former steel instead of lower. This fact seemed so peculiar that the additions and losses of manganese and phosphorus were studied with the results given in Table 61.

TABLE 61.—MANGANESE AND PHOSPHORUS LOSSES, 1919 EXPERIMENT.

	R21.	T21.	R22.	T22.
Weight of steel in ladle.....pounds..	74,600.	64,900.	49,500.	81,900.
Eighty per cent ferro-manganese added....do..	250.	250.	250.	250.
Manganese in above.....do..	200.	200.	200.	200.
Resulting increase in manganese.....per cent..	.268	.308	.404	.244
Calculated excess manganese content over other ladle.....do..	.....	.040	.160	.....
Actual excess manganese content over other ladle.....do..	.023	.....	.075	.....
Excess loss of manganese over other ladle.....do..	.....	.063	.085	.....
Eighteen per cent ferro-phosphorus added.....pounds..	325.	325.	325.	325.
Phosphorus in above.....do..	58.5	58.5	58.5	58.5
Resulting increase in phosphorus.....per cent..	.0784	.0902	.1182	.0715
Calculated excess phosphorus content over other ladle.....do..	.....	.0118	.0467	.....
Actual excess phosphorus content over other ladle.....do..	.0139	.....	.0199	.....
Excess loss of phosphorus over other ladle.....do..	.....	.0257	.0288	.....
Number of ingots poured before specials.....	2	2	2	2
Number of ingots poured after 3 specials.....	10½	8¼	2¾	11
Comparative temperature as shown by ladle skull.....	Same	Same	Colder	Hotter

	R23.	T23.	R24.	T24.
Weight of steel in ladle.....pounds..	66,100.	78,800.	71,900.	59,900.
Eighty per cent ferro-manganese added.....do..	250.	250.	250.	250.
Manganese in above.....do..	200.	200.	200.	200.
Resulting increase in manganese.....per cent..	.303	.254	.278	.334
Calculated excess manganese content over other ladle.....do..	.049	.....	.....	.056
Actual excess manganese content over other ladle.....do..	.018	.....	.008	.....
Excess loss of manganese over other ladle.....do..	.031	.....	.....	.064
Eighteen per cent ferro-phosphorus added.....pounds..	325.	325.	325.	325.
Phosphorus in above.....do..	58.5	58.5	58.5	58.5
Resulting increase in phosphorus.....per cent..	.0885	.0743	.0814	.0976
Calculated excess phosphorus content over other ladle.....do..	.0142	.....	.....	.0162
Actual excess phosphorus content over other ladle.....do..	.0004	.....	.0287	.....
Excess loss of phosphorus over other ladle.....do..	.0138	.....	.....	.0449
Number of ingots poured before specials.....	2	2	2	2
Number of ingots poured after 3 specials.....	6	10	9	5
Comparative temperature as shown by ladle skull.....	Colder	Hotter	Hotter	Colder

In Table 61 the residual manganese and phosphorus contents in the steel before the additions were made were not known, but they must have been the same for both portions of each heat, hence may be neglected in considering comparative (not actual) losses. This table shows that the titanium could not have caused the lower manganese and phosphorus contents of the treated portions of the heats, because two of the four heats showed a greater loss of these elements in the untreated ladles, and the other two showed a greater loss in the treated ladles. It is believed that the explanation should be based on the known tendency of the slag covering the ladle to absorb manganese and phosphorus from the metal below it. The total absorptive effect of the slag was proportional to the area of contact between slag and metal, hence was practically equal in both ladles of any heat. But the amount of metal acted on was not the same in each ladle, so that the slag, in removing equal quantities of phosphorus and manganese from the steel, necessarily reduced the percentage content more in the ladle containing the smaller amount of steel. This would explain why the ladle containing less steel showed greater losses of manganese and phosphorus in every heat. The absorptive effect of the slag was naturally more noticeable in these divided heats than in ordinary practice, for when the whole heat is put in one ladle, a large amount of slag runs over the top of the ladle, so that less remains to act on the steel; the area of contact between slag and metal of the heat is only the cross-sectional area of one ladle instead of two; and the total amount of steel acted upon in the one ladle is of course much greater than it was in either ladle of a divided heat.

If we assume a rather slow diffusion of manganese and phosphorus between the steel near the bottom of the ladle and that near the slag, another explanation is possible. The steels analyzed were obtained in every case from the third, fourth and fifth ingots poured, and no record was made of the analysis of the steel left in any of the ladles after the pouring of the fifth ingot. In heats 1 and 4 the steel forming these special ingots was nearer the slag in the treated ladle than in the untreated, as shown by the data in the table on the number of ingots poured from each ladle after the three specials. Since the basic slag tends to absorb phosphorus and manganese from the steel, and assuming a rather slow diffusion of these elements in the steel while the ladle was being held and the first few ingots poured, the special ingots from the treated ladles of heats 1 and 4 might be expected to show greater loss of phosphorus and manganese than the special ingots from the untreated ladles of these heats, because the former were poured from steel which lay closer to the slag in the ladle than the steel which formed the latter and which was therefore subjected more strongly to the slag's absorptive power. The same reasoning applied to heats 2 and 3 explains why in these heats the untreated special ingots showed greater loss of manganese and phosphorus than the treated. Possibly, temperature effects enter into these losses also, by controlling the reactions which cause them, for in three heats the ladles showing the greatest losses of these elements also contained the largest skulls after teeming, and in the other one the skull was estimated the same in both ladles.

Further data which are not available would be required to determine which of these two explanations applied more closely to each heat. Both may be equally true in all of them. It has been shown clearly, however, that the losses of these elements from the steel were connected in some way with the unequal division of the heats between the ladles, and were not influenced by the titanium treatment of the steel.

APPENDIX VII.—TENSILE TESTS OF SHEET BARS.

The specimens used for the tensile tests were cut from the sample sheet bars as shown by a diagram (Page 43). Crosswise tensile tests were made in both the 1917 and 1919 experiments. The pieces 15 inches long and 2½ inches wide, marked "A" on the diagram, were used for the tests. The central part of each piece was reduced to 1½ inches width for a distance of 8 inches by milling and filing accurately, but the flat sides were left as rolled, with the scale on, so that the thickness of the test specimen was the same as that of the rolled plate. The tests were made on an Olsen tensile testing machine of 100,000 pounds capacity, of the 3-screw type, and with an automatic attachment for keeping the beam balanced

TABLE 62.—RESULTS OF TRANSVERSE TENSILE TESTS, 1917 EXPERIMENT.

REGULAR STEEL.

Samples.	Yield point.	Tensile strength.	Elongation in 8 inches.	Reduction of area.	Fracture appearance.	Laminations.
	Lbs. per sq. in.	*Lbs. per sq. in.*	*Per cent.*	*Per cent.*		
R1a	37,900	53,400	30.8	58.7	Silky, ang.	S.
R1b	36,000	55,800	25.4	50.3	Silky, cup.	M
R1c	36,000	54,800	28.1	54.6	Silky, ang.	M
R1d	34,600	52,300	27.0	51.6	Cryst.	B
CR1a	40,300	56,200	20.7	53.8	Silky, ang.	S
CR1b	38,500	57,200	25.8	49.6	do.	B
CR1c	38,800	56,300	26.2	53.3	do.	B
CR1d	38,400	54,100	29.3	58.2	do.	B
R2a	43,600	65,300	20.3	39.9	Cryst.	B
R2b	41,600	63,300	21.1	44.4	do.	B
R2c	41,800	63,000	21.9	49.5	Silky, ang.	S
R2d	40,600	53,900	.....	.....	Piped.	.....
CR2a	49,300	65,200	12.1	34.9	Cryst.	B
CR2b	47,800	66,300	23.1	43.5	do.	B
CR2c	48,900	66,100	21.3	44.2	Silky, ang.	B
CR2d	51,000	64,400	19.9	43.8	Cryst.	B
R3a	44,400	63,000	18.0	35.7	Silky, cup.	B
R3b	40,800	60,200	24.6	43.6	Silky, ang.	B
R3c	40,800	59,000	25.4	52.3	do.	M
R3d	44,300	57,000	28.2	64.4	do.	S
CR3a	40,800	57,700	16.4	35.5	do.	B
CR3b	42,300	61,800	25.8	49.8	do.	B
CR3c	42,300	59,900	25.8	48.2	do.	B
CR3d	41,300	57,800	27.0	58.8	do.	M
R4a	37,000	52,100	.....	.....	Pipe.	.....
R4b	37,400	58,400	22.1	51.9	Silky, ang.	S
R4c	37,800	57,300	24.2	54.1	do.	S
R4d	36,100	47,000	.....	.....	Pipe.	.....
R5a	37,000	54,700	18.7	30.5	Cryst.	B
R5b	36,200	54,700	28.9	50.6	Silky, ½ cup.	M
R5c	37,900	54,400	23.8	45.5	do.	B
R5d	36,000	49,200	31.3	60.6	Silky, ang.	B
R6a	35,000	49,300	.....	.....	Pipe.	.....
R6b	39,800	57,900	25.0	52.1	Silky, ang.	M
R6c	39,900	58,400	24.5	50.3	do.	M
R6d	39,800	54,900	26.2	56.3	Silky, cup.	S
R7a	41.500	59.400	21.5	50.3	Silky, ang.	M
R7b	37,900	57,300	28.1	50.5	do.	B
R7c	39,100	56,300	25.4	51.4	do.	M
R7d	36,600	53,200	26.2	58.4	do.	M

(i. e., the load weighed) at all times. The smallest cross-sectional area of each specimen was found, before testing, with micrometer calipers, and a distance of 8 inches was accurately punched on the filed edge. The specimen was held in the machine with wedge-shaped grips, and loaded by running the cross-head down at a speed of about ¼ inch per minute. The yield point was found by noting the load when the drop of the beam occurred, and dividing this load by the cross-sectional area which was measured before testing. After the yield point was passed, the speed of the machine was increased to about 1 inch per minute, and the test-bar was elongated until it broke. The highest load obtained was read on the beam and divided by the original area to give the tensile strength.

TABLE 62.—RESULTS OF TRANSVERSE TENSILE TESTS, 1917 EXPERIMENT.—*Continued.*

TITANIUM-TREATED STEEL.

Samples.	Yield point.	Tensile strength.	Elongation in 8 inches.	Reduction of area.	Fracture appearance.	Laminations.
	Lbs. per sq. in.	*Lbs. per sq. in.*	*Per cent.*	*Per cent.*		
T1a	35,800	51,400	.....	.....	Piped.	.....
T1b	36,300	56,700	24.8	52.3	Silky, ang.	M
T1c	36,000	57,100	24.2	48.4	do.	B
T1d	36,700	53,300	27.3	55.0	Cryst.	B
CT1a	38,700	55,200	.....	.....	Piped.	.....
CT1b	39,800	59,300	28.1	48.5	Silky, ang.	B
CT1c	38,700	57,200	26.6	46.1	do.	B
CT1d	37,600	53,800	25.4	54.2	Cryst.	B
T2a	39,000	54,800	22.3	39.2	Silky, ang.	S
T2b	38,900	56,700	24.6	50.1	do.	M
T2c	41,200	55,800	27.0	54.4	do.	B
T2d	30,700	51,000	27.4	65.6	do.	No
CT2a	39,900	58,300	21.1	47.0	do.	S
CT2b	38,000	56,000	23.5	51.3	do.	B
CT2c	39,400	54,600	25.0	49.6	do.	M
CT2d	39,400	54,600	29.7	59.6	do.	M
T3a	40,600	53,400	22.3	62.0	do.	No
T3b	38,800	55,900	25.4	51.0	do.	M
T3c	39,700	55,400	24.6	52.8	do.	S
T3d	32,600	49,700	26.8	54.5	do.	Seam
CT3a	40,900	53,800	25.4	51.0	Silky, cup.	Seam
CT3b	40,800	58,100	25.8	52.5	Silky, ang.	M
CT3c	40,300	56,200	25.8	54.7	do.	S
CT3d	38,900	52,200	27.0	58.4	do.	S
T4a	44,400	64,400	23.0	43.6	do.	M
T4b	39,200	61,700	22.3	50.6	do.	S
T4c	39,700	60,100	26.2	49.2	Silky, ½ cup.	M
T4d	39,700	57,200	26,2	46,2	Silky, ang.	No
T5a	42,000	65,000	18.0	35.2	do.	M
T5b	40,800	62,300	22.7	44.2	do.	B
T5c	40,300	60,500	25.8	48.4	do.	S
T5d	39,100	55,900	28.5	54.1	do.	S
T6a	39,800	55,600	.....	.....	Piped.	.....
T6b	38,600	58,700	23.7	52.0	Silky, ang.	S
T6c	38,900	56,900	25.0	55.4	do.	S
T6d	34,500	53,500	26.7	53.9	do.	S
T7a	37,800	55,200	20.3	57.2	do.	B
T7b	40,100	57,800	25.0	63.7	do.	B
T7c	40,200	57,600	22.7	50.6	do.	M
T7d	33,600	53,200	22.7	55.6	do.	S

The two ends of the bar were removed from the machine and placed on a bench with the fractured ends together, as they were immediately before rupture. The distance between the gage points, which had been 8 inches apart before testing, was then measured, and the per cent of elongation was obtained by dividing the increase in hundredths of an inch by 8, the original length in inches. The cross-sectional area of the fracture was measured with micrometer calipers, and the per cent of reduction of area was determined by dividing the difference between the original and final areas by the original area. The zero adjustment of the machine was checked up at the beginning of each test, with the motor running and the test bar held only in the upper grip. The loads were read to the nearest

TABLE 63.—RESULTS OF LENGTHWISE TENSILE TESTS, 1917 EXPERIMENT.

REGULAR STEEL.

Samples.	Yield point.	Tensile strength.	Elongation in 2 inches.	Reduction of area.	Fracture appearance.	Laminations.
	Lbs. per sq. in.	*Lbs. per sq. in.*	*Per cent.*	*Per cent.*		
R1a	34,200	53,200	48.0	68.9	Silky, ang.	S
R1b	35,800	57,400	42.5	61.5	Silky, ½ cup.	S
R1c	34,900	56,100	44.5	62.8	Silky, ang.	S
R1d	34,900	53,100	47.0	63.0	Silky.	S
CR1a	38,100	56,600	46.0	63.8	do.	M
CR1b	38,400	58,200	43.0	61.9	do.	S
CR1c	37,400	57,900	46.0	61.4	do.	No
CR1d	38,900	54,900	46.0	66.8	do.	No
R2a	43,000	67,200	30.0	38.0	Cryst.	B
R2b	41,200	64,100	38.5	53.8	Silky, ½ cup.	S
R2c	42,300	64,400	39.0	50.7	do.	S
R2d	41,000	61,000	41.0	61.1	Silky, ang.	S
CR2a	42,400	64,400	.....	26.4	Cryst.	B
CR2b	43,600	66,800	35.5	48.1	Silky, ang.	B
CR2c	47,300	66,500	36.0	48.2	do.	B
CR2d	47,500	62,600	38.0	57.6	Silky, cup.	S
R3a	44,100	65,300	32.5	46.3	Cryst.	B
R3b	40,400	61,000	40.0	61.1	Silky, cup.	M
R3c	38,300	60,100	42.5	60.1	Silky, ½ cup.	S
R3d	41,900	57,500	43.0	64.3	Silky, ang.	S
CR3a	39,400	59,300	39.0	38.4	Silky, ½ cup.	Seam
CR3b	39,500	61,100	40.5	57.4	Silky, ang.	B
CR3c	41,900	60,800	41.0	58.4	Silky, cup.	S
CR3d	37,900	57,200	42.0	65.2	do.	S
R4a	36,300	58,100	42.0	55.2	Silky, ang.	No
R4b	36,900	59,200	43.0	57.9	do.	S
R4c	36,200	58,800	41.5	57.6	Silky, cup.	S
R4d	36,900	54,600	46.5	64.2	Silky, ang.	No
R5a	37,100	53,000	.....	39.3	Cryst.	B
R5b	37,300	55,600	42.5	54.9	Silky, ang.	S
R5c	36,900	55,800	44.5	60.6	do.	No
R5d	34,800	51,400	50.0	72.2	Silky, cup.	No
R6a	40,000	60,900	37.5	47.6	do.	M
R6b	39,000	60,400	40.6	59.3	Silky, ang.	M
R6c	38,300	58,900	39.1	58.4	do.	S
R6d	40,400	57,700	45.3	62.7	do.	S
R7a	38,500	58,200	40.0	51.4	Silky, cup.	B
R7b	39,100	58,400	42.0	57.1	Silky, ½ cup	M
R7c	38,700	57,300	42.5	57.6	Silky, cup.	M
R7d	40,900	57,100	45.5	63.7	Silky, ang.	S

ten pounds, but the stresses were computed only to the nearest hundred pounds, as greater accuracy is not obtainable with the mechanism employed. The sectional dimensions were measured to the nearest thousandth of an inch and the elongation to the nearest hundredth.

Lengthwise tensile tests were made in the 1917 experiment only, on the pieces marked "B" on the diagram, which were as long as the sample strips were wide. With most of the samples an 8-inch gauge length was impossible, so all these bars were made with a gauge length of 2 inches. Otherwise the preparation of these test pieces was the same as described for the crosswise tensile tests. The tests were made on the same machine and in the same manner as the crosswise tests

TABLE 63.—RESULTS OF LENGTHWISE TENSILE TESTS, 1917 EXPERIMENT.—*Continued.*

TITANIUM-TREATED STEEL.

Samples.	Yield point.	Tensile strength.	Elongation in 2 inches.	Reduction of area.	Fracture appearance.	Laminations.
	Lbs. per sq. in.	*Lbs. per sq. in.*	*Per cent.*	*Per cent.*		
T1a	37,200	57,800	41.0	55.1	Silky, ½ cup.	S
T1b	37,100	57,200	42.5	61.4	Silky, cup	No
T1c	35,600	57,000	44.0	61.7	Silky, ang.	S
T1d	37,700	54,300	45.5	66.0	do.	No
CT1a	41,700	60,900	37.5	40.3	do.	S
CT1b	38,700	60,000	42.5	57.9	do.	S
CT1c	36,500	58,600	42.5	59.2	do.	No
CT1d	40,800	56,000	43.5	64.0	do.	No
T2a	41,400	60,700	37.5	50.3	do.	S
T2b	39,300	57,400	43.0	63.1	do.	No
T2c	35,200	56,800	44.0	63.9	do.	No
T2d	29,300	50,100	48.5	64.2	do.	Seam
CT2a	39,000	59,600	38.5	51.9	do.	M
CT2b	37,600	57,000	42.5	57.2	Silky, ¾ cup.	No
CT2c	36,400	56,100	45.5	64.8	Silky, ang.	S
CT2d	39,800	54,400	49.0	70.4	do.	No
T3a	36,700	52,900	46.0	62.4	Silky, ½ cup.	B
T3b	39,000	56,500	43.5	64.3	Silky, ang.	S
T3c	38,800	55,800	43.5	64.3	Silky, ½ cup.	No
T3d	28,800	48,700	48.5	66.8	Silky, ang.	No
CT3a	42,000	57,600	42.5	54.3	Silky, ½ cup.	M
CT3b	39,600	57,800	42.5	62.0	Silky, ang.	No
CT3c	38,900	57,300	45.0	62.5	Silky, cup.	S
CT3d	39,000	54,400	46.5	70.0	Silky, ang.	No
T4a	41,800	65,600	36.5	49.7	Silky, cup.	B
T4b	39,000	61,800	40.0	54.1	Silky, ang.	S
T4c	39,000	61,700	41.0	58.5	do.	No
T4d	37,800	55,900	44.5	65.9	Silky, cup.	Seam
T5a	43,400	66,600	34.0	41.8	Silky, ang.	B
T5b	39,800	62,900	41.5	59.5	do.	B
T5c	39,800	62,000	39,0	55.8	do.	S
T5d	38,000	58,200	46.0	64.0	do.	M
T6a	43,500	63,700	32.8	42.8	do.	B
T6b	38,800	59,800	40.6	56.5	do.	S
T6c	36,800	55,100	42.2	58.5	Silky, ½ cup.	No
T6d	35,200	52,300	45.3	62.7	Silky, ang.	Seam
T7a	37,000	59,100	37.5	45.9	do.	B
T7b	40,100	60,000	43.0	61.3	do.	M
T7c	39,300	58,300	43.0	60.9	do.	M
T7d	30,100	51,000	46.0	64.6	do.	S

described above, but the elongations were measured in only 2 inches instead of 8 inches.

For the fracture remarks in Tables 62, 63 and 64 the following abbreviations are used: "Ang." means that the fracture was angular in shape, and "Cryst." means that its surface was brightly crystalline instead of dull and silky. Under "Laminations," the letter B stands for "Bad," meaning that these streaks were present in the fracture to a serious extent. "S" in this column means that only slight laminations were present, while "M" means that they were of medium

TABLE 64.—RESULTS OF TRANSVERSE TENSILE TESTS, 1919 EXPERIMENT.

REGULAR STEEL.

Samples.	Yield point.	Tensile strength.	Elongation in 8 inches.	Reduction of area.	Fracture appearance.	Laminations.
	Lbs. per sq. in.	*Lbs. per sq. in.*	*Per cent.*	*Per cent.*		
R21c*	37,500	54,500	20.3	59.2	Silky, cup.	No
R21h	35,700	53,600	25.8	55.9	Silky, ang.	No
R21i	35,900	50,600	30.1	49.4	Silky, cup.	Seam
CR21c	35,300	53,500	25.1	55.3	Silky, ang.	B
CR21h	36,100	54,300	26.8	56.7	Silky, cup.	No
CR21i	35,700	50,500	28.0	58.3	Silky, ang.	No
SR21c*	37,900	59,500	.....	.....	Pipe.	.....
SR21h	36,700	57,800	21.3	48.0	Silky, ang.	B
SR21i	39,000	55,100	31.8	59.0	Silky, ½ cup.	No
R22c	42,900	63,900	16.3	36.2	Cryst., cup.	B
R22h	39,300	59,800	26.3	41.1	Silky, ang.	No
R22i*	34,500	46,500	10.3	.....	Pipe.	.....
CR22c	45,400	64,800	23.5	38.4	Silky, ang.	B
CR22h	42,500	61,100	26.5	44.0	Silky, ½ cup.	B
CR22i*	40,800	45,100	10.5	.....	Pipe.	.....
SR22c*	42,400	63,100	17.6	24.1	Silky, ang.	B
SR22h	45,900	63,700	24.9	41.8	Silky, cup.	S
SR22i*	47,100	62,700	12.4	.....	Pipe.	.....
R23c*	39,900	57,800	19.9	52.8	Silky, cup.	B
R23h	38,900	55,800	27.6	52.0	do.	B
R23i*	35,600	51,100	30.7	.....	Pipe.	.....
CR23c	41,100	56,900	17.0	53.7	Silky, ang.	B
CR23h	40,900	56,800	26.6	50.9	Silky, ½ cup.	No
CR23i*	35,600	43,400	19.1	.....	Pipe.	.....
SR23c*	41,600	59,700	24.4	42.2	Silky, ang.	B
SR23h	38,900	56,200	27.9	46.8	Silky, ½ cup.	B
SR23i	.....	.....	.....	.....	Pipe.	.....
R24c	46,000	66,800	21.8	35.6	Silky, ½ cup.	B
R24h	40,500	59,700	27.6	47.6	do.	B
R24i*	32,100	51,900	18.6	.....	Pipe.	.....
CR24c	45,800	65,500	17.5	42.9	Silky, ¾ cup.	B
CR24h	44,700	61,100	24.0	46.6	Silky, ½ cup.	B
CR24i	39,600	55,900	25.9	41.0	Silky, ang.	Seam
SR24c*	43,900	60,100	13.8	.....	Pipe.	.....
SR24h	44,700	63,000	28.4	42.8	Silky, ¾ cup.	B
SR24i*	.....	.....	.....	.....	Pipe.	.....

*Result for this sample not used in computing averages (except under fracture appearance), because either this bar or corresponding titanium-treated bar was piped.

prominence, between "slight" and "bad." "No" means that none at all were seen. A "Cup" fracture is one in which the end of one broken stub is cone-shaped all around its edge, fitting into the cup-shaped end of the other stub; and "half-cup" means that each stub was cup-shaped half way around its edge, and cone-shaped for the other half.

The results for the samples marked with an asterisk in the 1919 experiment were not used in computing average results, as explained in the text of the report, because either those bars or the corresponding bars from the same heat were piped.

TABLE 64.—RESULTS OF TRANSVERSE TENSILE TESTS, 1919 EXPERIMENT.—*Continued.*

TITANIUM-TREATED STEEL.

Samples.	Yield point.	Tensile strength.	Elongation in 8 inches.	Reduction of area.	Fracture appearance.	Laminations.
	Lbs. per sq. in.	*Lbs. per sq. in.*	*Per cent.*	*Per cent.*		
T21c*	32,100	43,800	18.6	26.0	Pipe.	.....
T21h	34,500	51,200	23.5	57.5	Silky, ang.	No
T21i	33,100	49,500	34.0	63.3	Silky, ½ cup.	No
CT21c	36,900	54,000	22.1	59.2	Silky, cup.	No
CT21h	36,900	52,400	26.5	58.6	Silky, ang.	No
CT21i	41,300	51,300	29.0	57.4	Silky, ½ cup.	B
ST21c*	38,500	58,100	19.6	24.3	do.	B
ST21h	37,200	55,400	28.0	51.6	Silky, ang.	No
ST21i	37,300	55,400	28.4	44.5	Silky, ½ cup.	B
T22c	37,900	54,900	25.0	47.1	Silky, ang.	S
T22h	37,400	57,200	26.1	47.1	Silky, ½ cup.	No
T22i*	37,400	53,000	27.3	.....	Pipe.	.....
CT22c	37,900	60,300	22.5	48.0	Silky, ½ cup.	No
CT22h	39,000	58,500	27.1	50.2	Silky, ang.	S
CT22i*	37,500	52,700	14.0	.....	Pipe.	.....
ST22c*	39,700	56,300	11.9	.....	do.	.....
ST22h	39,900	58,800	20.5	25.7	Silky, ang.	B
ST22i*	36,200	52,200	17.4	.....	Pipe.	.....
T23c	.....	.....	.....	.....	do.	.....
T23h	38,500	56,100	26.4	47.5	Silky, ang.	No
T23i*	37,200	55,800	10.8	53.2	do.	No
CT23c	38,400	53,500	22.0	59.0	do,	No
CT23h	38,200	56,200	27.5	54.2	Silky, cup.	No
CT23i	.....	.....	.....	.....	Pipe.	.....
ST23c*	40,000	57,200	13.3	.....	Do.	.....
ST23h	37,400	57,000	27.9	48.5	Silky, ang.	No
ST23i*	39,200	57,700	21.5	48.0	Silky, cup.	B
T24c	38,600	61,100	24.5	44.0	Silky, ang.	B
T24h	41,700	59,700	24.8	43.3	do.	B
T24i*	40,000	55,800	29.0	33.9	Silky, ½ cup.	B
CT24c	42,900	64,400	23.5	42.9	Silky, cup.	B
CT24h	41,300	61,500	24.5	43.2	Silky, ½ cup.	B
CT24i	39,400	54,000	11.5	18.1	Silky, ang.	B
ST24c*	39,700	60,300	19.1	22.8	do.	Seam
ST24h	38,700	61,100	24.8	40.6	do.	B
ST24i*	42,500	60,400	24.5	44.3	Silky, ¾ cup.	B

*Result for this sample not used in computing averages (except under fracture appearance), because either this bar or corresponding regular bar was piped.

APPENDIX VIII.—IMPACT TESTS OF SHEET BARS.

The impact tests were made in different ways in the two experiments, so the methods must be described separately. In the 1917 experiment the ⅝-inch strip marked "C" on the diagram (page 43) was used for these tests, and was planed and filed accurately to a cross-section of ½ by ¼ inch for a length of about 4 inches. The specimen was so machined that its half-inch faces were paralled to the scaled surface of the plate and the same distance (about ⅛ inch) from the surface on each side. The machine used for these tests was made by T. Olsen & Co., after the design of Dr. McAdam of the U. S. N. Engineering Experiment Station at Annapolis, Md. The test bar is clamped in a vise at the base of the machine, with its end extending upward beyond the vise for a distance of about ⅜ inch. A pendulum is suspended from an axis directly above the vise and carries a shear blade which has a clearance of about 1/64 inch above the jaws of the vise. To make a test on the steel specimens, the pendulum was raised to a height sufficient to give a blow equivalent to 200 foot-pounds of energy, and dropped on the specimen in the vise. After shearing the specimen the pendulum swung upward a certain distance, carrying a pointer with it, which was left at the highest point of the swing, thus registering the energy not used up in the shear. By subtracting this from the total energy generated, or 200 foot-pounds, the energy used in shearing the specimen was obtained. The machine could be calibrated as often as desired by merely letting the pendulum swing, without any test specimen in the vise, and adjusting the pointer so that the total energy developed was recorded accurately. In testing these steel specimens three shears about ⅜ inch apart were made on each one, and each specimen was placed in the vise so that the shear-blade struck against its half-inch face.

Impact-shear tests were not made on the sheet bars from the 1919 experiment, but instead of this test, notched-bar impact tests were made. The same pendulum-type machine was used, but with the axle or shaft raised above the vise or specimen-holder so that the clearance or striking distance was 0.823 inch (20.9 mm.) instead of about 1/64 inch. The test-pieces were 10 by 10 millimeters in section and were cut perpendicular to the rolling direction of the sheet bar, extending from about the middle of the sheet bar for a distance of about 6 inches. These 10 by 10 millimeter bars were notched carefully with a hacksaw 3 millimeters deep on the side parallel to the narrow edge of the sheet bar, 28 millimeters from the end of the bar, and at intervals of 28 millimeters along the 6-inch length, until four notches had been made. The bar was set in the machine with the top of the vise even with the middle of the first (or uppermost) notch and a blow of 200 foot-pounds was delivered against the protruding end of the bar in a direction parallel with the rolling direction of the sheet bar. The reading of energy used in breaking the notched specimen was taken in exactly the same way as was done with the impact-shear tests of the 1917 experiment. The bar was then moved up in the vise to the next notch, and another blow delivered, and so on until four tests were made on each bar. The four tests on any one bar usually agreed fairly well, but owing to the transverse manner of cutting the bar, segregated streaks in the sheet bar would naturally cause more or less variation in the results. It was found, however, that unless the tests were made parallel to the laminations in the specimen, in the direction specified above, the metal was often too ductile to break and the test became unsatisfactory.

In the following tables individual and average results for each test bar are given, expressed as foot-pounds of energy used in breaking the bar.

TABLE 65.—RESULTS OF IMPACT-SHEAR TESTS, 1917 EXPERIMENT.

Regular steel.			Titanium-treated steel.		
Samples.	Energy as foot pounds.		Samples.	Energy as foot pounds.	
	Individual results.	Average.		Individual results.	Average.
R1a	65–65–67	66	T1a	63- 64–64	64
R1b	66–68–68	67	T1b	67–67–67	67
R1c	68–68–68	68	T1c	67–67–68	67
R1d	68–69–69	69	T1d	68–67–67	67
CR1a	76–77–76	76	CT1a	67–65–64	65
CR1b	73–73–70	72	CT1b	67–68–69	68
CR1c	64–66–66	65	CT1c	66–65–66	66
CR1d	70–68–68	69	CT1d	68–68–70	69
R2a	64–61–63	63	T2a	65–64–63	64
R2b	62–61–63	62	T2b	68–67–67	67
R2c	64–61–62	62	T2c	70–69–70	70
R2d	66–68–68	67	T2d	71–71–71	71
CR2a	64–62–63	63	CT2a	59–57–57	58
CR2b	66–64–66	65	CT2b	69–69–68	69
CR2c	63–63–64	63	CT2c	68–68–67	68
CR2d	68–69–73	70	CT2d	69–69–69	69
R3a	58–57–58	58	T3a	70–72–71	71
R3b	65–64–66	65	T3b	64–64–66	65
R3c	66–66–67	66	T3c	70–69–71	70
R3d	68–67–67	67	T3d	68–71–69	69
CR3a	65–63–64	64	CT3a	67–67–67	67
CR3b	64–66–66	65	CT3b	65–65–65	65
CR3c	67–67–68	67	CT3c	63–64–64	64
CR3d	66–67–67	67	CT3d	66–67–68	67
R4a	58–59–60	59	T4a	59–60–61	60
R4b	66–68–68	67	T4b	70–69–72	70
R4c	67–66–68	67	T4c	68–68–67	68
R4d	68–68–68	68	T4d	69–69–69	69
R5a	63–63–62	63	T5a	65–63–63	64
R5b	63–65–64	64	T5b	61–62–63	62
R5c	69–71–70	70	T5c	62–61–61	61
R5d	73–72–73	73	T5d	67–68–67	67
R6a	72–73–73	73	T6a	75–73–72	73
R6b	66–68–66	67	T6b	70–70–70	70
R6c	65–65–65	65	T6c	69–68–67	68
R6d	69–70–68	69	T6d	68–69–66	68
R7a	65–64–63	64	T7a	61–63–60	61
R7b	64–64–63	64	T7b	62–64–64	63
R7c	64–66–66	65	T7c	67–70–68	68
R7d	68–69–69	69	T7d	69–71–71	70

TABLE 66.—RESULTS OF NOTCHED-BAR IMPACT TESTS, 1919 EXPERIMENT.

Regular steel.			Titanium-treated steel.		
Samples.	Energy in foot pounds.		Samples.	Energy in foot pounds.	
	Individual results.	Average.		Individual results.	Average.
R21c	45–48–44–63	50.0	T21c	74–63–67–57	65.2
R21h	50–48–49–51	49.5	T21h	60–54–46–49	52.2
R21i*	Split		T21i*	54–49–54–58	53.7
CR21c*	63–45–52–43	50.7	CT21c*	Split	
CR21h	46–47–53	48.7	CT21h	61–56–58–55	57.5
CR21i	56–58–61–51	56.5	CT21i	54–66–57–49	56.5
SR21c	36–46–42–38	40.5	ST21c	36–33–34–34	34.2
SR21h	34–36–34–32	34.0	ST21h	38–37–39–34	37.0
SR21i	47–45–45–48	46.2	ST21i	39–37–36–34	36.5
R22c	28–30–28–20	26.5	T22c	35–37–38–37	36.8
R22h	38–37–38–38	37.8	T22h	38–40–38–39	38.8
R22i*	40–43–47–46	44.0	T22i*	Split	
CR22c	26–32–33–35	31.5	CT22c	35–39–35–34	35.8
CR22h	40–42–40–39	40.3	CT22h	40–38–41–41	40.0
CR22i	37–42–43–42	41.0	CT22i	47–48–44–47	46.5
SR22c	38–42–38–41	39.8	ST22c	37–38–37–39	37.8
SR22h	26–32–31–29	29.5	ST22h	35–39–39–37	37.5
SR22i	22–28–30–25	26.3	ST22i	38–39–37–38	38.0
R23c	45†–44†–43†–42†	43.5	T23c	37†–40†–38–37	38.0
R23h	43†–43†–47†–52	46.2	T23h	42–43–38–41	41.0
R23i*	48†–55–58–54	53.7	T23i*	Split	
CR23c	49†–47†–47†–46†	47.2	CT23c	31–34–33–32	32.5
CR23h	42–48–48†–50	47.0	CT23h	38–36–37–38	37.2
CR23i*	61†–64–72–66	65.7	CT23i*	Split	
SR23c	40–41–40–38†	39.7	ST23c	35†–32†–31†–31†	32.2
SR23h	28–32–29–31	30.0	ST23h	35†–35†–38†–35†	35.7
SR23i*	Split		ST23i*	36–36–35–33	35.0
R24c	15–20†–15–17	16.7	T24c	22–24–24–22	23.0
R24h	27–26–26–25†	26.0	T24h	24–22–24–24	23.5
R24i*	Split		T24i*	27–28–24–26†	26.2
CR24c	16–18–18†–17	17.2	CT24c	24–24–25–25	24.5
CR24h	28–29–30–29	29.0	CT24h	24–24–24–24	24.0
CR24i	47–45–46–43	45.2	CT24i	25–22–23–23	23.2
SR24c*	Split		ST24c*	24†–23–24–27†	24.5
SR24h	23–23–22†–21†	22.2	ST24h	24–23–23–23†	23.2
SR24i*	Split		ST24i*	Split	

*Results for this sample not used in computing averages in the text of the report because either this bar or corresponding bar was piped or split.

†Small seam found opened up in this fracture.

APPENDIX IX.—ALTERNATING-IMPACT TESTS OF SHEET BARS.

These tests in both experiments were made with the Landgraf-Turner machine. The specimen was a rod about 8 inches long, turned in a lathe to exactly ⅜ inch in diameter, and polished with emery cloth to eradicate all tool marks. One end of this rod was clamped rigidly in a vise at the base of the machine, while the other end projected upward through a slot in a rocker arm, which was rapidly vibrated backward and forward when the machine was in motion. The slot was ¾ inch long and moved far enough so that the test bar was bent ⅜ inch forward by the rear end of the slot and ⅜ inch backward by its front end. The slot was 4⅛ inches above the vise holding the lower end of the test bar, so that the angle of bend was about six degrees in each direction, which was enough to exceed the elastic limit and give a slight permanent set to the steel at each bend. Since the slot was ¾ inch long, and the test bar only ⅜ inch in diameter, there was a short period of rest between each bend, and each bend was produced by a sudden blow, thus making the test one of alternating impact rather than alternate bending. The speed was such that the blows were repeated at the rate of about 400 per minute. A counter on the machine recorded the number of revolutions from the start of each test till fracture took place, and one unit on the counter indicated 30 alternations or blows against the test specimen. In these tests the alternations were counted for each specimen until actual separation of the specimen had taken place. As failure always occurred at the end held in the vise, a second test was made on each bar, placing the opposite end in the vise, and in the 1917 experiment turning the bar on its axis so that the second bending was in a direction at right angles to that of the first. In the 1919 experiment, however, the bending of both ends of every test piece was caused to take place in the same direction, in the plane of the sheet bar or in a plane perpendicular to the smallest dimension or thickness of the sheet bar. Thus, in the 1919 experiment the individual results on the same test piece should theoretically agree, while in the 1917 experiment they could not be expected to be alike, as the two bendings were in different directions.

The specimens were machined from half-inch strips cut parallel to the direction of rolling near the middle of the sheet bar, as shown at "D" on the diagram on page 43. They were made 8 inches long, or as long as possible if the sheet-bar sample was less than 8 inches wide. Individual results are tabulated below, except in the case of the second heat in the 1919 experiment, where through a mistake the results from the two ends of the bars were counted together instead of separately.

TABLE 67.—RESULTS OF ALTERNATING-IMPACT TESTS, 1917 EXPERIMENT.

Regular steel.			Titanium-treated steel.		
Samples.	Indicator readings.	Average alternations endured.	Samples.	Indicator readings.	Average alternations endured.
R1a	31–36	1,005	T1a	24–32	840
R1b	40–37	1,155	T1b	37–46	1,245
R1c	35–41	1,140	T1c	52–27	1,185
R1d	40–41	1,215	T1d	35–38	1,095
CR1a	30–37	1,005	CT1a	21–25	690
CR1b	34–25	885	CT1b	43–38†	1,215
CR1c	29–38	1,005	CT1c	38–40	1,170
CR1d	35–34	1,035	CT1d	38–46	1,260
R2a	37–26	945	T2a	20–40	900
R2b	35–28	945	T2b	34–36	1,050
R2c	28–39	1,005	T2c	30–33	945
R2d	38–28	990	T2d	45–37	1,230
CR2a	15–19	510	CT2a	17–37	810
CR2b	38–28	990	CT2b	32–33	975
CR2c	26–33	885	CT2c	40–36	1,140
CR2d	28–31*	885	CT2d	34–36	1,050
R3a	16–42	870	T3a	35–28*	945
R3b	46–42	1,320	T3b	37–35	1,080
R3c	42–42	1,260	T3c	31–40	1,065
R3d	42–39	1,215	T3d	39–62	1,515
CR3a	44*–11	825	CT3a	36–34	1,050
CR3b	26–37	945	CT3b	33–35	1,020
CR3c	28–41	1,035	CT3c	38–27	975
CR3d	43–32	1,125	CT3d	39–40	1,185
R4a	16–46	930	T4a	43–19	930
R4b	28–44	1,080	T4b	46–47	1,395
R4c	44–40	1,260	T4c	38–33	1,065
R4d	41–44	1,275	T4d	45–47	1,380
R5a	22–43	975	T5a	31–23	810
R5b	26–39	975	T5b	39–42	1,215
R5c	38–26	960	T5c	37–32	1,035
R5d	33–36	1,035	T5d	39–38	1,155
R6a	47–21	1,020	T6a	19–26	675
R6b	39–42	1,215	T6b	27–35	930
R6c	26–43	1,035	T6c	34–41	1,125
R6d	37–29	990	T6d	39†*–46	1,275
R7a	45-20	975	T7a	30–12	630
R7b	43–36	1,185	T7b	29–39	1,020
R7c	38–41	1,185	T7c	39–42	1,215
R7d	48–35	1,245	T7d	63-43	1,590

*Noticeable seam opened up in the test piece.

†Spring connection at the top end of the bar worked loose, necessitating an interruption of the test while it was tightened.

TABLE 68.—RESULTS OF ALTERNATING-IMPACT TESTS, 1919 EXPERIMENT.

Regular steel.			Titanium-treated steel.		
Samples.	Indicator readings.	Average alternations endured.	Samples.	Indicator readings.	Average alternations endured.
R21c	24–30	810	T21c	30–44	1,110
R21h	42–34	1,140	T21h	38–43	1,215
R21i*	Split	.....	T21i*	45–48	1,395
CR21c*	16–21	555	CT21c*	Split	.....
CR21h	42–45†	1,305	CT21h	29–19	720
CR21i	42–43	1,275	CT21i	48–49	1,455
SR21c	39–39	1,170	ST21c	35–34	1,035
SR21h	48–39	1,305	ST21h	42–35	1,155
SR21i	43–44	1,305	ST21i	44–41	1,275
R22c	35	525	T22c	35	525
R22h	41	615	T22h	41	615
R22i*	83	1,245	T22i*	Split	.....
CR22c	20	300	CT22c	34	510
CR22h	59	885	CT22h	70	1,050
CR22i	59	885	CT22i	81	1,215
SR22c	70	1,050	ST22c	77	1,155
SR22h	76	1,140	ST22h	85	1,275
SR22i	68	1,020	ST22i	78	1,170
R23c	21–29	750	T23c	17–14	465
R23h	19–38	855	T23h	29–25	810
R23i*	35–43	1,170	T23i*	Split	.....
CR23c	14–19	495	CT23c	10–10	300
CR23h	19–16	525	CT23h	37–26	945
CR23i*	32–49	1,215	CT23i*	Split	.....
SR23c	27–25	780	ST23c	34–31	975
SR23h	28–35	945	ST23h	··–39	1,170
SR23i*	Split	.....	ST23i*	30–30	900
R24c	14–11	375	T24c	11–12	345
R24h	23–30	795	T24h	33–31	960
R24i*	Split	.....	T24i*	41–40	1,215
CR24c	14–10	360	CT24c	24–22	690
CR24h	39–27	990	CT24h	37–26	945
CR24i	25–30	825	CT24i	38–33	1,065
SR24c	9–9	270	ST24c	34–22	840
SR24h	34–36	1,050	ST24h	41–39	1,200
SR24i*	Split	.....	ST24i*	Split	.....

*Results from these samples were omitted from the general averages in the text of the report, because these or corresponding test bars were split, as explained under tensile tests.

†Spring connection at the top end of the bar worked loose, necessitating an interruption of the test while it was tightened.

APPENDIX X.—HARDNESS TESTS OF SHEET BARS.

The remainders of the ½ and ¼ inch filed bars left after the impact-shear tests had been made were used for hardness tests in the 1917 experiment. A half-inch face of each bar was filed again with a very fine file, and a hardened steel ball of 10 millimeters diameter was pressed into the surface by a load of 1,000 kilograms maintained for 30 seconds. This was done with the standard Brinell hardness testing machine. The load was applied by an oil pump with a governor so weighted that the desired pressure could not be exceeded by pumping too much. The ball was pressed into the surface of each specimen at three different places in the same way, and the diameters of the depressions were measured to the nearest twentieth of a millimeter with a microscope carrying in the field of view a transparent scale graduated to tenths of a millimeter. The Brinell hardness number, which is arbitrarily taken as the pressure divided by the area of the depression, was obtained from each depression diameter measurement by means of the following formula:

$$\text{Hardness} = \text{Pressure} \times \frac{r + \sqrt{r^2 - R^2},}{2\pi r R^2}$$

where r is the radius of the ball, and R the radius of the depression. Since the pressure in this case was 1,000, and r is always 5, the hardness is determined by R, which is half the measured diameter, in the formula in this form:

$$H = \frac{100\,(5 + \sqrt{25 - R^2})}{\pi R^2}$$

The standard pressure for steel is supposed to be 3,000 kilograms, and for softer materials 500 kilograms, but in this case the former load would have necessitated the preparation of larger specimens, and the latter load would have given such small depressions as to make their accurate measurement very difficult. Since a load of 1,000 kilograms was adopted for aluminum bronze for the same reasons, it was decided to use it also for these soft steels, and avoid the expense of careful preparation of larger specimens especially for this test. The results are all given in Table 69. No hardness tests were made in the 1919 experiment.

TABLE 69.—RESULTS OF HARDNESS TESTS, 1917 EXPERIMENT.

Regular steel.			Titanium-treated steel.		
Samples.	Diameters of depressions.	Average hardness.	Samples.	Diameters of depressions.	Average hardness.
	Millimeters.	*Brinell No.*		*Millimeters.*	*Brinell No.*
R1a	3.4–3.4	107	T1a	3.3–3.3	113
R1b	3.4–3.4	107	T1b	3.4–3.4	107
R1c	3.4–3.4	107	T1c	3.4–3.3	110
R1d	3.6–3.6	95	T1d	3.6–3.5	98
CR1a	3.4–3.3	110	CT1a	3.2–3.2	121
CR1b	3.3–3.4	110	CT1b	3.2–3.3	117
CR1c	3.5–3.5	101	CT1c	3.3–3.4	110
CR1d	3.4–3.5	104	CT1d	3.4–3.5	104
R2a	3.2–3.2	121	T2a	3.4–3.4	107
R2b	3.2–3.1	125	T2b	3.4–3.4	107
R2c	3.3–3.3	113	T2c	3.4–3.4	107
R2d	3.3–3.3	113	T2d	3.6–3.6	95
CR2a	2.9–2.9	148	CT2a	3.2–3.2	121
CR2b	3.2–3.1	125	CT2b	3.4–3.4	107
CR2c	3.1–3.1	129	CT2c	3.2–3.3	117
CR2d	3.1–3.1	129	CT2d	3.4–3.4	107
R3a	3.3–3.3	113	T3a	3.4–3.5	104
R3b	3.4–3.3	110	T3b	3.2–3.2	121
R3c	3.3–3.3	113	T3c	3.5–3.5	101
R3d	3.2–3.2	121	T3d	3.6–3.6	95
CR3a	3.1–3.1	129	CT3a	3.4–3.4	107
CR3b	3.2–3.1	125	CT3b	3.4–3.4	107
CR3c	3.2–3.2	121	CT3c	3.3–3.3	113
CR3d	3.3–3.3	113	CT3d	3.4–3.4	107
R4a	3.4–3.4	107	T4a	3.2–3.2	121
R4b	3.3–3.3	113	T4b	3.2–3.2	121
R4c	3.3–3.3	113	T4c	3.3–3.3	113
R4d	3.4–3.4	107	T4d	3.4–3.4	107
R5a	3.3–3.3	113	T5a	3.3–3.3	113
R5b	3.4–3.5	104	T5b	3.2–3.2	121
R5c	3.3–3.3	113	T5c	3.3–3.4	110
R5d	3.3–3.4	110	T5d	3.3–3.4	110
R6a	3.2–3.1	125	T6a	3.1–3.2	125
R6b	3.1–3.1	129	T6b	3.1–3.2	125
R6c	3.1–3.1	129	T6c	3.3–3.4	110
R6d	3.3–3.3	113	T6d	3.3–3.3	113
R7a	3.5–3.5	101	T7a	3.3–3.3	113
R7b	3.2–3.2	121	T7b	3.3–3.3	113
R7c	3.3–3.3	113	T7c	3.3–3.3	113
R7d	3.4–3.4	107	T7d	3.5–3.4	104

APPENDIX XI.—ATMOSPHERIC CORROSION TESTS OF SHEET BARS.

The loss in weight of the various kinds of steel of the 1919 experiment during exposure to the weather was determined on specimens cut from the sample sheet bars representing the middle of every ingot.. Even the ingots treated with both silicon and copper were used in this work, although they were not used in the other tests of sheet bars. Thirty-two samples were taken for the rusting tests, and a rectangular rod ½ inch by ⅛ inch by 4 inches long was cut from each of them for a test specimen. These specimens were located midway between the center and edge of the rolled bar, with the ½-inch dimension perpendicular to the surface of the bar, and the ½-inch by 4-inch face parallel to its rolled edge. The scale was all ground off these rods and 3/16-inch holes were drilled through them at one end, so that they could be hung up for the test with all sides equally exposed. They were then carefully cleaned and accurately weighed, the weights ranging from 37.2036 grams to 38.0024 grams. The rods were suspended from short glass tubes placed through the 3/16-inch holes, and copper wires passed through the glass tubes to a board which carried all the rods in the same way. This board was placed on supports on the roof of the physical testing laboratory of the Titanium Alloy Manufacturing Company at Niagara Falls, New York, on November 6, 1920, so that the rods hung freely from it with all sides exposed equally to the weather. The glass tubes did not resist very well the swinging of the rods in the wind, so that before the test was finished the glass had practically disappeared, and the rods were hanging directly from the copper wires.

Early in December, January, March and May the board carrying the rods was brought into the laboratory for a few hours for inspection of the rust that had formed. Notes were made at these times as to the color, texture, and looseness of the rust on each side of every rod. No very definite or consistent conclusions, however, can be drawn from these notes. At the earlier inspection the copper-bearing samples appeared in general somewhat darker in color than those without copper; and at the later inspections the rust seemed to be looser on most of the non-copper rods than it was on those containing copper; but there were exceptions to both of these general conclusions.

In May 1921, after six months' exposure, the rods were all taken from the board brushed as clean as possible, and left over night in a hot ammoniacal ammonium citrate solution whose strength was about 5 per cent. This apparently removed all the rust, leaving the rods pitted and gray in color. The next day they were washed in alcohol, dried in an oven, carefully weighed, and exposed again on the roof in the same way as before, except that the glass tubes were omitted in suspending them from the board.

In July the rods were taken down and inspected, but all had about the same appearance, with dark brown fine crumbly rust. The differences shown after rusting by the original specimens were entirely lacking in these pitted specimens. They were put back on the roof and left there until November 10, 1921, when they were finally taken down for inspection, cleaning, and weighing. The inspection again showed no differences in appearance, and the cleaning and weighing were performed in the same way as before. The results, expressed as percentage of the original weight lost, are presented in the tables following.

TABLE 70.—LOSS IN WEIGHT BY ATMOSPHERIC CORROSION OF SAMPLES FROM SHEET BARS OF EACH TYPE OF STEEL, 1919 EXPERIMENT.

Samples.	Loss in weight.			
	First six months.	Second six months.	Total.	Average total loss.
Heat 21.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Regular:				
Plain	3.32	3.61	6.93	6.59 / 6.73
Copper-bearing	2.92	3.32	6.24	
Silicon-treated	3.58	3.62	7.20	6.87
Silicon-copper	3.16	3.38	6.54	
Titanium-treated:				
Plain	3.38	3.80	7.18	6.88 / 6.87
Copper-bearing	2.98	3.60	6.58	
Silicon-treated	3.46	3.65	7.11	6.87
Silicon-copper	3.09	3.53	6.62	
Heat 22.				
Regular:				
Plain	3.22	3.77	6.99	6.45 / 6.42
Copper-bearing	2.68	3.22	5.90	
Silicon-treated	3.24	3.61	6.85	6.39
Silicon-copper	2.75	3.17	5.92	
Titanium-treated:				
Plain	3.30	3.81	7.11	6.60 / 6.54
Copper-bearing	2.74	3.34	6.08	
Silicon-treated	3.36	3.73	7.09	6.48
Silicon-copper	2.65	3.22	5.87	
Heat 23.				
Regular:				
Plain	3.28	3.95	7.23	6.77 / 6.67
Copper-bearing	2.86	3.44	6.30	
Silicon-treated	3.30	3.70	7.00	6.58
Silicon-copper	2.75	3.40	6.15	
Titanium-treated:				
Plain	3.46	3.79	7.25	6.62 / 6.69
Copper-bearing	2.51	3.47	5.98	
Silicon-treated	3.44	3.83	7.27	6.76
Silicon-copper	2.84	3.40	6.24	
Heat 24.				
Regular:				
Plain	3.36	3.83	7.19	6.68 / 6.58
Copper-bearing	2.79	3.37	6.16	
Silicon-treated	3.32	3.49	6.81	6.49
Silicon-copper	2.82	3.34	6.16	
Titanium-treated:				
Plain	3.30	3.76	7.06	6.46 / 6.47
Copper-bearing	2.51	3.35	5.86	
Silicon-treated	3.28	3.71	6.99	6.48
Silicon-copper	2.67	3.29	5.96	
All heats.				
Regular:				
Plain	3.30	3.79	7.09	6.62 / 6.60
Copper-bearing	2.81	3.34	6.15	
Silicon-treated	3.36	3.61	6.97	6.58
Silicon-copper	2.87	3.32	6.19	
Titanium-treated:				
Plain	3.36	3.79	7.15	6.64 / 6.64
Copper-bearing	2.69	3.44	6.13	
Silicon-treated	3.39	3.73	7.12	6.64
Silicon-copper	2.81	3.36	6.17	

TABLE 71.—LOSS IN WEIGHT BY ATMOSPHERIC CORROSION OF SAMPLES FROM COPPER-BEARING AND NON-COPPER-BEARING SHEET BARS, 1919 EXPERIMENT.

Samples.	Loss in weight.		
	First six months.	Second six months.	Total loss.
Heat 21.	*Per cent.*	*Per cent.*	*Per cent.*
Regular:			
Copper-bearing	3.45	3.62	7.07
Non-copper-bearing	3.04	3.35	6.39
Difference	.41	.27	.68
Titanium-treated:			
Copper-bearing	3.42	3.73	7.15
Non-copper-bearing	3.04	3.56	6.60
Difference	.38	.17	.55
Heat 22.			
Regular:			
Copper-bearing	3.23	3.69	6.92
Non-copper-bearing	2.72	3.19	5.91
Difference	.51	.50	1.01
Titanium-treated:			
Copper-bearing	3.33	3.77	7.10
Non-copper-bearing	2.70	3.28	5.98
Difference	.63	.49	1.12
Heat 23.			
Regular:			
Copper-bearing	3.29	3.83	7.12
Non-copper-bearing	2.81	3.42	6.23
Difference	.48	.41	.89
Titanium-treated:			
Copper-bearing	3.45	3.81	7.26
Non-copper-bearing	2.68	3.43	6.11
Difference	.77	.38	1.15
Heat 24.			
Regular:			
Copper-bearing	3.34	3.66	7.00
Non-copper-bearing	2.81	3.35	6.16
Difference	.53	.31	.84
Titanium-treated:			
Copper-bearing	3.29	3.74	7.03
Non-copper-bearing	2.58	3.33	5.91
Difference	.71	.41	1.12
All heats.			
Copper-bearing	3.35	3.73	7.08
Non-copper-bearing	2.80	3.36	6.16
Difference	.55	.37	.92

These results do not show any difference in rust resistance between the steels with or without titanium or silicon, but copper is shown to have had a surprisingly consistent effect in retarding this rusting. In every kind of steel tested, without exception, the copper-bearing specimen lost less weight in this experiment than the corresponding specimen without copper, and not one of the copper-bearing rods lost as much weight as the best of the non-copper in the same time. There was less difference in the first heat than in the others, because the copper-bearing steel in this heat had a decidedly lower copper content than in the other heats.

While the losses in weight were greater for the second six months, in summer, than they were for the first, or winter, period, the differences between the copper-bearing and non-copper steels were greater for the first six months. This may have been due either to outside causes, such as temperature, or to the different condition of the surface of the rods at the start of the two periods.

On the average, the addition of 0.2 per cent copper to the steel decreased the loss in weight by about 1 per cent of the original weight in twelve months. However, this period was actually composed of two periods of six months each, with a thorough cleaning of the specimens at the end of the first. If the rust coatings had been untouched for the entire twelve months, it is probable that a greater effect of the copper content would have been found, because this effect consists largely, if not entirely, in increasing the density and protective character of the rust formed.

APPENDIX XII.—METALLOGRAPHIC TESTS OF SHEET BARS.

TABLE 72.—SLAG AND SULPHIDE INCLUSIONS, MACROSTRUCTURE, PEARLITE DISTRIBUTION, AND GRAIN SIZE AS SHOWN BY MICROSCOPIC EXAMINATION OF POLISHED SECTIONS OF SHEET BARS, 1917 AND 1919 EXPERIMENTS.

1917 EXPERIMENT.

Regular steel.							Titanium-treated steel.						
Samples.		Slag inclusions.	Sulphide inclusions.	Macro-structure.	Pearlite distribution.	Grain size.	Samples.		Slag inclusions.	Sulphide inclusions.	Macro-structure.	Pearlite distribution.	Grain size.
R1a	Center.	Medium	Medium	Fair	Mediocre	Small	T1a	Center.	Very small	Medium	Poor	Mediocre	Small
	Edge.	Small	Small	Good	Uniform	do.		Edge.	do.	Very small	Good	Uniform	Very small
R1b	Center.	do.	Large	Bad	Poor	do.	T1b	Center.	do.	Large	Fair	Bad	Small
	Edge.	do.	Medium	Fair	Mediocre	do.		Edge.	do.	Small	Good	Uniform	do.
R1c	Center.	Medium	Large	Bad	Poor	do.	T1c	Center.	Small	Very large	Poor	Bad	do.
	Edge.	Small	Very small	Fair	Uniform	do.		Edge.	Very small	Small	Fair	Mediocre	do.
R1d	Center.	do.	Large	Bad	Poor	do.	T1d	Center.	Small	do.	do.	Uniform	Very small
	Edge.	do.	Very small	Fair	Mediocre	do.		Edge.	Medium	Medium	Poor	Mediocre	do.
CR1a	Center.	Medium	Medium	Bad	do.	do.	CT1a	Center.	Very small	Large	Good	Uniform	do.
	Edge.	Very small	Very small	Good	Uniform	do.		Edge.	Small	Very small	do.	do.	do.
CR1b	Center.	Large	Very large	Bad	Bad	do.	CT1b	Center.	do.	Large	Fair	Poor	Small
	Edge.	Very small	Very small	Fair	Mediocre	do.		Edge.	do.	Medium	Bad	do.	do.
CR1c	Center.	Medium	Large	Bad	Bad	do.	CT1c	Center.	Medium	do.	Good	do.	do.
	Edge.	Small	Medium	Fair	Uniform	do.		Edge.	Small	Small	do.	Mediocre	do.
CR1d	Center.	do.	Small	Bad	Mediocre	Very small	CT1d	Center.	Medium	do.	Fair	Uniform	do.
	Edge.	Very small	Medium	do.	do.	do.		Edge.	Small	do.	do.	Mediocre	do.
R2a	Center.	Medium	Very large	Very bad	Bad	Small	T2a	Center.	Very small	Large	Bad	Bad	do.
	Edge.	do.	Medium	Poor	Mediocre	do.		Edge.	Small	Very small	Good	Uniform	do.
R2b	Center.	do.	do.	do.	Bad	do.	T2b	Center.	do.	Medium	Fair	Bad	do.
	Edge.	do.	do.	Fair	Mediocre	do.		Edge.	Very small	Very small	Good	Uniform	do.
R2c	Center.	do.	do.	Bad	Bad	do.	T2c	Center.	Medium	Medium	Poor	Poor	do.
	Edge.	Small	Large	Poor	Poor	do.		Edge.	do.	Very small	Fair	Uniform	Medium]
R2d	Center.	Medium	Small	do.	Bad	do.	T2d	Center.	Very small	do.	Poor	Poor	Large
	Edge.	do.	do.	Fair	Poor	Very small		Edge.	Small	do.	Fair	Uniform	do.
CR2a	Center.	Small	Very large	Bad	Very bad	do.	CT2a	Center.	Very small	Large	Poor	Poor	Small
	Edge.	Medium	Small	do.	Bad	do.		Edge.	do.	Small	Good	Uniform	do.
CR2b	Center.	do.	Very large	Very bad	Very bad	Small	CT2b	Center.	do.	Medium	Fair	Poor	do.
	Edge.	Small	Medium	Bad	Bad	Very small		Edge.	do.	Small	Good	Uniform	Medium
CR2c	Center.	Medium	do.	do.	do.	Small	CT2c	Center.	Small	Medium	Fair	Mediocre	Small
	Edge.	Small	Very large	do.	do.	do.		Edge.	Medium	Small	do.	Uniform	do.
CR2d	Center.	Medium	Very small	do.	do.	Very small	CT2d	Center.	Very small	Very small	Poor	do.	do.
	Edge.	do.	Small	do.	Poor	Small		Edge.	Small	Small	Fair	do.	do.
R3a	Center.	Small	Medium	do.	Very bad	do.	T3a	Center.	Very small	do.	Poor	Mediocre	do.
	Edge.	Very small	Very small	Good	Uniform	do.		Edge.	do.	Very small	Good	Uniform	do.
R3b	Center.	Small	Small	Bad	Bad	do.	T3b	Center.	Small	Medium	Poor	Poor	do.
	Edge.	do.	Medium	do.	do.	do.		Edge.	Very small	Very small	Good	Uniform	do.

R3c...	Center.	Medium	do.	do.	do.	do.	T3c...	Center.	Medium	Small	Poor	Poor	do.
	Edge..	do.	do.	do.	do.	do.		Edge..	Small	do.	Good	Uniform	do.
R3d...	Center.	Small	Small	Poor	Poor	do.	T3d...	Center.	do.	do.	do.	Mediocre	Large
	Edge..	Medium	do.	do.	Mediocre	Very small		Edge..	Medium	do.	Fair	Uniform	do.
CR3a..	Center.	Very large	Small	Bad	Poor	Small	CT3a..	Center.	Small	Large	Bad	Bad	Small
	Edge..	Medium	do.	Good	Uniform	do.		Edge..	Very small	Very small	Good	Uniform	do.
CR3b..	Center.	Small	do.	Bad	Bad	do.	CT3b..	Center.	Very large	Medium	Bad	Poor	do.
	Edge..	do.	Medium	do.	do.	do.		Edge..	Small	Small	Good	Uniform	do.
CR3c..	Center.	Medium	Small	Very bad	do.	do.	CT3c..	Center.	do.	Medium	Poor	Poor	do.
	Edge..	Small	Medium	do.	do.	do.		Edge..	do.	Small	Good	Uniform	do.
CR3d..	Center.	Medium	Very small	Poor	Poor	do.	CT3d..	Center.	do.	do.	Fair	Poor	do.
	Edge..	Very small	do.	Fair	Uniform	do.		Edge..	Medium	do.	do.	Uniform	do.
R4a...	Center.	Medium	Small	do.	Poor	Medium	T4a...	Center.	Small	Medium	Poor	Bad	do.
	Edge..	Small	do.	Good	Uniform	do.		Edge..	do.	Small	do.	Poor	do.
R4b. .	Center.	do.	Large	Poor	Poor	do.	T4b...	Center.	Medium	do.	Bad	Bad	do.
	Edge..	do.	Small	Good	Uniform	do.		Edge..	Small	do.	Good	Mediocre	do.
R4c...	Center.	Medium	Medium	Poor	Bad	do.	T4c...	Center.	Medium	do.	Bad	Bad	do.
	Edge..	do.	Small	Good	Uniform	do.		Edge..	Small	do.	Poor	Mediocre	do.
R4d...	Center.	Small	do.	Fair	do.	Small	T4d...	Center.	Large	do.	do.	do.	do.
	Edge..	Medium	do.	do.	do.	do.		Edge..	Medium	do.	do.	Uniform	do.
R5a...	Center.	do.	Very large	Poor	Poor	Medium	T5a...	Center.	Small	Large	do.	Bad	do.
	Edge..	Small	Very small	Good	Uniform	do.		Edge..	do.	Small	Fair	Mediocre	do.
R4c...	Center.	do.	Large	Poor	Bad	do.	T5b...	Center.	do.	Medium	Bad	Bad	do.
	Edge..	do.	Small	Good	Mediocre	do.		Edge..	do.	do.	Poor	do.	do.
R5c...	Center.	Medium	Large	Poor	Bad	Small	T5c...	Center.	Medium	Large	Bad	do.	do.
	Edge..	Small	Small	Good	Uniform	Medium		Edge..	Small	Medium	do.	do.	do.
R5d...	Center.	do.	do.	Fair	do.	Small	T5d...	Center.	Medium	do.	Fair	Poor	do.
	Edge..	Medium	do.	Good	do.	do.		Edge..	Large	Small	do.	do.	do.
R6a...	Center.	Small	Large	Poor	Bad	do.	T6a...	Center.	Small	Medium	Bad	Bad	do.
	Edge..	do.	Medium	Fair	Mediocre	do.		Edge..	do.	Small	Good	Uniform	do.
R6b...	Center.	do.	Large	Bad	Bad	do.	T6b...	Center.	Medium	Medium	Poor	Bad	do.
	Edge..	do.	Medium	Fair	Mediocre	do.		Edge..	Small	Small	Fair	Mediocre	do.
R6c...	Center.	Medium	Large	Bad	Bad	do.	T6c...	Center.	do.	do.	Poor	Bad	do.
	Edge..	do.	Medium	Poor	Poor	do.		Edge..	Very small	Very small	Good	Uniform	do.
R6d...	Center.	do.	Small	Fair	Mediocre	do.	T6d...	Center.	Medium	Small	Fair	Mediocre	do.
	Edge..	do.	Medium	Bad	Poor	do.		Edge..	do.	do.	Poor	Poor	Medium
R7a...	Center.	Small	Very small	Fair	Mediocre	do.	T7a...	Center.	Small	Medium	Bad	Bad	Small
	Edge..	do.	do.	Good	Uniform	do.		Edge..	do.	Very small	Fair	Uniform	Large
R7b...	Center.	do.	Medium	Very bad	Very bad	do.	T7b...	Center.	do.	Medium	Bad	Bad	Small
	Edge..	Very small	Small	Good	Uniform	do.		Edge..	Very small	Very small	Good	Uniform	Medium
R7c...	Center.	Medium	Medium	Bad	Bad	do.	T7c...	Center.	Medium	Medium	Poor	Poor	Small
	Edge..	Small	Small	Fair	Mediocre	do.		Edge..	Small	Very small	Good	Uniform	Medium
R7d...	Center.	Very small	do.	do.	do.	do.	T7d...	Center.	do.	Small	do.	Poor	Large
	Edge..	Medium	do.	do.	do.	do.		Edge..	Medium	do.	Poor	Bad	Medium

NOTE.—For significance of notes, see p. 60 and following.

TABLE 72.—SLAG AND SULPHIDE INCLUSIONS, MACROSTRUCTURE, PEARLITE DISTRIBUTION, AND GRAIN SIZE AS SHOWN BY MICROSCOPIC EXAMINATION OF POLISHED SECTIONS OF SHEET BARS, 1917 AND 1919 EXPERIMENTS.—*Continued.*

1919 EXPERIMENT.

Regular steel.						Titanium-treated steel.					
Samples.	Slag inclusions.	Sulphide inclusions.	Macro-structure.	Pearlite distribution.	Grain size.	Samples.	Slag inclusions.	Sulphide inclusions.	Macro-structure	Pearlite distribution.	Grain size.
R21c.. Center.	3–2	B	0	0	Medium	T21c.. Center.	2–1	B	0	1	Medium
R21c.. Edge..	3–3	U	2	3	do.	T21c.. Edge..	4–3	U	3	3	do.
R21h.. Center.	2–1	B	2	1	do.	T21h.. Center.	3–2	B	0	0	Large
R21h.. Edge..	3–2	U	3	3	do.	T21h.. Edge..	3–3	U	3	3	Medium
R21i... Center.	2–2	U	1	3	do.	T21i... Center.	3–2	U	2	3	do.
R21i... Edge..	2–1	U	1	3	do.	T21i... Edge..	3–2	U	2	3	do.
CR21c. Center.	3–2	B	0	0	Large	CT21c Center.	3–3	B	0	0	do.
CR21c. Edge..	3–3	U	3	3	Medium	CT21c Edge..	3–3	U	3	3	Large
CR21h. Center.	2–1	S	1	2	do.	CT21h. Center.	2–1	B	1	1	Medium
CR21h. Edge..	3–2	U	3	3	do.	CT21h. Edge..	3–2	U	3	3	do.
CR21i. Center.	2–2	U	1	3	do.	CT21i. Center.	2–1	S	2	3	do.
CR21i. Edge..	1–1	U	1	3	do.	CT21i. Edge..	2–2	U	1	3	do.
SR21c. Center.	1–0	U	1	0	do.	ST21c. Center.	1–1	U	1	1	do.
SR21c. Edge..	1–0	U	0	0	Small	ST21c. Edge..	1–1	U	2	2	do.
SR21h. Center.	1–1	U	2	1	Medium	ST21h. Center.	1–1	U	2	2	do.
SR21h. Edge..	1–1	U	3	2	do.	ST21h. Edge..	1–1	U	3	3	do.
SR21i.. Center.	2–2	U	1	2	do.	ST21i.. Center.	1–1	U	3	3	do.
SR21i.. Edge..	2–2	U	2	2	do.	ST21i.. Edge..	1–1	U	2	3	do.
R22c.. Center.	1–2	B	0	0	do.	T22c.. Center.	2–2	S	0	1	do.
R22c.. Edge..	3–3	B	0	0	do.	T22c.. Edge..	4–3	B	1	1	do.
R22h.. Center.	1–1	B	0	0	do.	T22h.. Center.	2–2	B	1	2	do.
R22h.. Edge..	3–2	B	1	0	do.	T22h.. Edge..	3–4	U	1	1	Large
R22i... Center.	2–2	U	1	2	do.	T22i... Center.	1–1	U	1	3	Medium
R22i... Edge..	2–2	U	3	3	Large	T22i... Edge..	1–1	U	1	3	do.
CR22c. Center.	2–1	S	0	0	Medium	CT22c. Center.	4–3	B	0	2	do.
CR22c. Edge..	4–3	B	0	0	do.	CT22c. Edge..	3–2	U	1	1	do.
CR22h. Center.	2–1	B	1	0	do.	CT22h. Center.	3–2	B	1	2	do.
CR22h. Edge..	2–2	B	0	0	do.	CT22h. Edge..	3–3	U	1	2	do.
CR22i. Center.	2–1	S	1	1	do.	CT22i. Center.	1–1	U	2	3	do.
CR22i. Edge..	3–2	U	1	3	do.	CT22i. Edge..	2–2	U	2	3	do.

SR22c.	Center.	1–1	S	2	1	Large	ST22c.	Center.	1–0	U	2	1	do.
	Edge..	1–1	U	2	1	do.		Edge..	1–2	U	3	2	do.
SR22h.	Center.	0–1	U	2	0	do.	ST22h.	Center.	1–1	U	2	1	do.
	Edge..	2–1	U	1	0	do.		Edge..	2–1	U	2	1	do.
SR22i .	Center.	1–0	U	2	1	do.	ST22i..	Center.	1–1	U	2	1	do.
	Edge..	1–1	U	2	2	do.		Edge..	1–1	U	0	0	do.
R23c..	Center.	3–2	B	0	0	Medium	T23c..	Center.	2–2	B	0	0	Medium
	Edge..	4–3	U	3	3	do.		Edge..	3–2	U	2	2	Large
R23h..	Center.	3–3	B	1	1	do.	T23h..	Center.	1–1	B	1	1	Medium
	Edge..	2–2	U	3	3	do.		Edge..	3–2	U	2	2	do.
R23i...	Center.	2–2	U	3	3	do.	T23i...	Center.	2–2	U	2	3	Large
	Edge..	1–0	U	2	1	Large		Edge..	2–1	U	2	2	do.
CR23c.	Center.	2–3	B	0	0	Medium	CT23c.	Center.	3–2	B	1	1	Medium
	Edge..	3–2	U	3	3	do.		Edge..	3–2	U	3	3	do.
CR23h.	Center.	2–1	B	0	1	do.	CT23h.	Center.	2–2	S	1	1	do.
	Edge..	3–3	U	2	3	Large		Edge..	3–2	U	2	2	do.
CR23i.	Center.	2–1	S	2	2	do.	CT23i.	Center.	2–2	U	2	3	Large
	Edge..	3–2	U	2	2	do.		Edge..	1–1	U	2	2	Medium
SR23c.	Center.	0–0	U	2	1	Medium	ST23c.	Center.	1–0	U	2	3	do.
	Edge..	1–1	U	3	2	do.		Edge..	2–1	U	2	2	do.
SR23h.	Center.	0–0	U	1	2	do.	ST23h.	Center.	1–1	U	3	2	do.
	Edge..	1–0	U	2	1	do.		Edge..	1–1	U	3	3	do.
SR23i..	Center.	2–2	U	2	3	Large	ST23i..	Center.	0–0	U	2	3	do.
	Edge..	2–1	U	2	2	do.		Edge..	1–1	U	1	1	Large
R24c..	Center.	3–2	B	0	1	Medium	T24c..	Center.	2–2	B	1	1	do.
	Edge..	3–3	S	1	1	do.		Edge..	2–2	U	1	2	do.
R24h..	Center.	2–2	B	1	1	do.	T24h..	Center.	2–1	U	2	0	Medium
	Edge..	2–2	B	0	0	do.		Edge..	1–0	B	0	1	do.
R24i...	Center.	2–1	U	2	3	Large	T24i...	Center.	1–1	U	3	3	Small
	Edge..	2–1	U	2	3	do.		Edge..	1–1	U	3	3	do.
CR24c.	Center.	3–2	B	1	1	Medium	CT24c	Center.	2–2	B	1	1	Medium
	Edge..	4–3	B	0	0	Small		Edge..	3–2	B	0	0	Small
CR24h.	Center.	2–1	B	1	1	Medium	CT24h.	Center.	1–1	B	1	1	Medium
	Edge..	3–2	B	0	1	do.		Edge..	1–1	U	0	0	do.
CR24i.	Center.	2–2	U	0	2	do.	CT24i.	Center.	1–1	U	3	3	do.
	Edge..	1–0	U	0	0	do.		Edge..	1–0	U	2	2	Large
SR24c.	Center.	1–1	U	2	1	Small	ST24c.	Center.	0–1	U	2	2	Medium
	Edge..	1–1	U	2	1	do.		Edge..	2–2	U	3	3	do.
SR24h.	Center.	1–1	S	2	1	Medium	ST24h.	Center.	1–1	U	2	2	do.
	Edge..	1–1	B	2	1	Small		Edge..	2–2	U	2	2	do.
SR24i..	Center.	1–0	U	2	1	Large	ST24i..	Center.	1–1	U	3	3	do.
	Edge..	1–1	S	2	1	do.		Edge..	1–1	U	2	2	Small

APPENDIX XIII.—ROLLING, ANNEALING AND TINNING OF SHEETS.

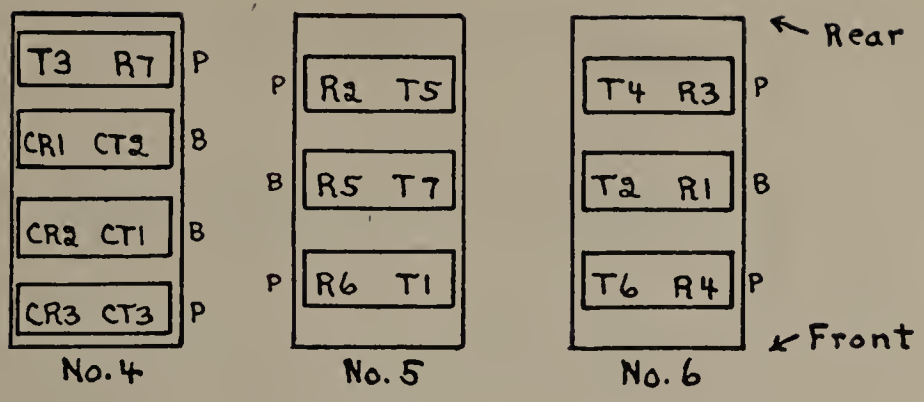
TABLE 73.—LOSSES IN OPENING AND TIME REQUIRED FOR OPENING ROLLED SHEETS, 1917 AND 1919 EXPERIMENTS.

1917 EXPERIMENT.

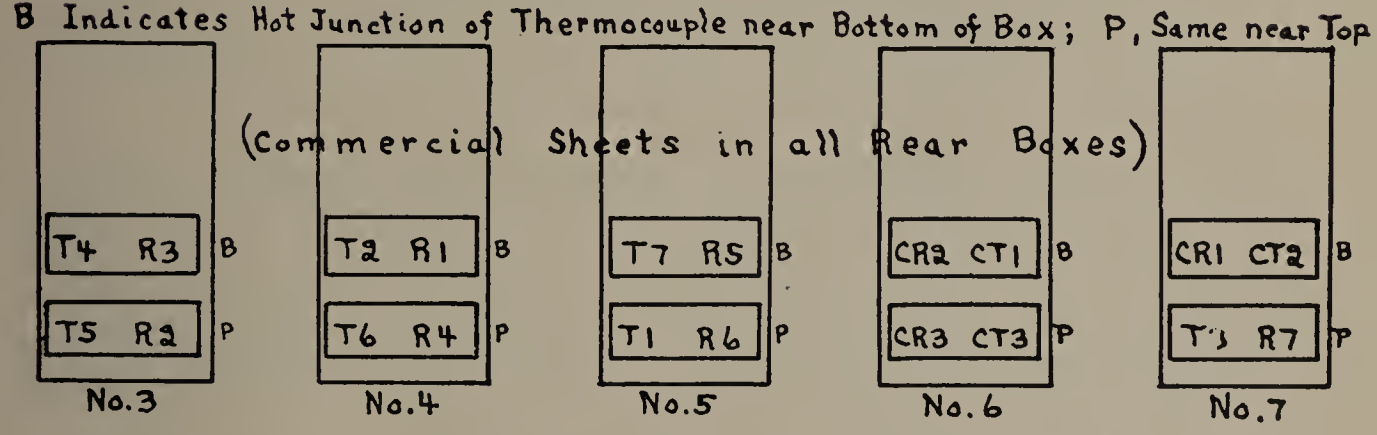
Regular steel.					Titanium-treated steel.				
Sheets.	Weight of rolled. sheets	Spoiled in opening.	Time required for opening.	Quality as to ease of opening.	Sheets.	Weight of rolled sheets.	Spoiled in opening.	Time required for opening.	Quality as to ease of opening.
	Pounds.	*Per cent.*	*Hours.*			*Pounds.*	*Per cent.*	*Hours.*	
R1	4,022	3.5	7.0	.....	T1	4,667	1.6	5.0	.....
CR1	4,687	1.4	4.5	.....	CT1	5,004	1.0	5.0	.....
R2	4,177	1.1	5.0	.....	T2	4,868	1.6	5.0	.....
CR2	4,494	1.1	5.0	.....	CT2	5,245	.3	5.0	.....
R3	4,667	1.0	5.5	.....	T3	4,245	.8	5.0	.....
CR3	4,677	.8	8.0	.....	CT3	4,805	.9	4.0	.....
R4	4,610	2.5	5.0	.....	T4	4,640	1.1	4.0	.....
R5	4,597	7.0	10.0	.....	T5	4,795	1.2	4.5	.....
R6	4,398	1.9	5.0	.....	T6	4,865	2.5	7.5	.....
R7	4,535	.9	5.0	.....	T7	4,700	.8	4.0	.....

1919 EXPERIMENT.

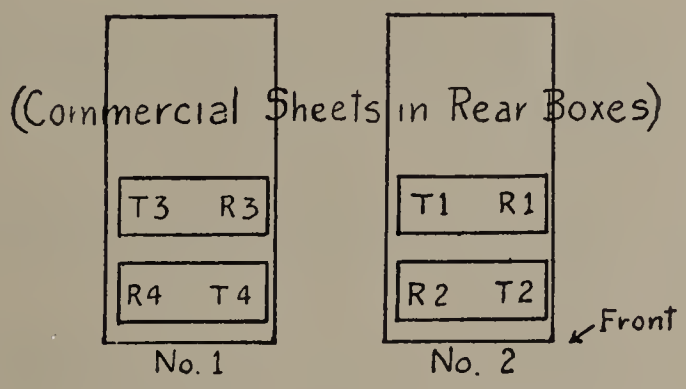
R21	930	6.4	3.3	Bad	T1	895	3.9	4.4	Very bad
CR21	900	5.0	3.6	Very bad	CT1	900	7.8	4.1	do.
SR21	900	1.7	.9	Good	ST1	885	.6	.....	Bad
SCR21	895	3.9	1.1	Bad	SCT1	895	3.4	1.5	do.
R22	855	2.9	.....	do.	T2	880	.6	.....	do.
CR22	850	.0	.....	Very good	CT2	910	8.2	2.6	do.
SR22	900	.0	.....	do.	ST2	980	11.2	.9	Good
SCR22	915	4.4	.....	do.	SCT2	920	7.1	.....	do.
R23	930	7.5	5.0	Very bad	T3	930	15.1	4.2	Very bad
CR23	910	4.4	3.3	Bad	CT3	880	9.1	.....	Bad
SR23	910	8.8	2.0	do.	ST3	830	1.2	1.2	.....
SCR23	905	4.4	2.8	do.	SCT3	915	3.3	1.6	.....
R24	930	8.1	1.8	do.	T4	925	9.2	1.2	Bad
CR24	935	7.0	.....	Good	CT4	875	1.1	1.0	Good
SR24	930	8.6	1.0	do.	ST4	925	9.7	.9	do.
SCR24	910	7.2	.6	do.	SCT4	925	3.8	.7	do.



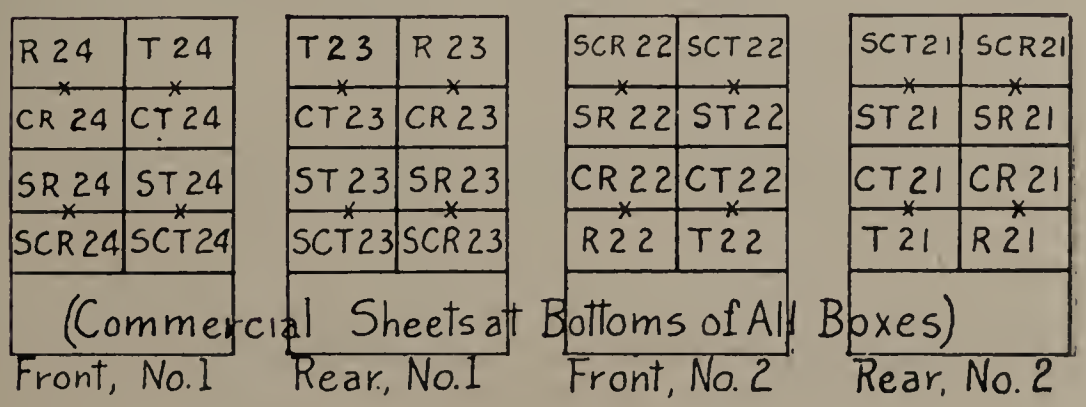
Plan of Furnaces.
Black Annealing, 1917 Experiment.



Plan of Furnaces
White Annealing, 1917 Experiment.



Plan of Furnaces
Both Annealings, 1919 Experiment



Elevation of Boxes
Both Annealings, 1919 Experiment
x Indicates Hot Junction of Thermocouple

FIG. 125.—Arrangement of lots of sheets in the annealing furnaces.

TABLE 74.—TEMPERATURES OF BLACK ANNEALING, 1917 EXPERIMENT.

Hours in furnace.	Furnace 4; couple[a] in—					Furnace 5; couple[a] in—				Furnace 6; couple[a] in—			
	Door.	CT3 (CR3).	CT1 (CR2).	CT2 (CR1).	R7 (T3).	Door.	R6 (T1).	R5 (T7).	R2 (T5).	Door.	R4 (T6).	R1 (T2).	R3 (T4).
	Deg. F.	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*
2.0	.....	.....	.....	.....	.....	1,135	270	.....	215	1,110	215	205	215
3.0	.....	.....	.....	.....	.....	1,255	410	215	440	1,225	350	225	475
3.5	.....	300	200	200	470	1,280	490	220	550	1,295	440	280	585
4.0	.....	.....	.....	.....	.....	1,345	620	280	680	1,330	535	340	720
4.5	1,170	440	270	280	700	1,380	745	345	825	1,350	640	430	865
5.0	.....	.....	.....	.....	.....	1,375	855	415	925	1,365	740	510	975
5.5	1,260	550	340	350	850	1,360	945	500	1,025	1,325	830	600	1,075
6.0	.....	.....	.....	.....	.....	1,370	1,015	575	1,110	1,340	895	675	1,135
6.5	1,260	720	480	495	1,030	1,385	1,065	660	1,170	1,365	960	755	1,195
7.0	.....	.....	.....	.....	.....	1,390	1,120	735	1,230	1,370	1,015	820	1,245
7.5	1,280	835	610	625	1,155	1,435	1,160	805	1,275	1,395	1,065	895	1,290
8.0	.....	.....	.....	.....	.....	1,455	1,205	880	1,315	1,405	1,115	965	1,330
8.5	1,330	940	725	745	1,240	1,475	1,240	940	1,360	1,430	1,155	1,020	1,365
9.0	1,340	980	780	805	1,275	1,450	1,275	1,010	1,405	1,435	1,190	1,080	1,405
9.5	1,400	1,030	830	865	1,315	1,435	1,310	1,060	1,450	1,440	1,225	1,135	1,450
10.0	1,410	1,060	890	925	1,345	1,475	1,335	1,130	1,490	1,440	1,260	1,185	1,485
10.5	1,360	1,100	935	980	1,380	1,500	1,360	1,165	1,535	1,465	1,280	1,225	1,525
11.0	1,420	1,135	985	1,030	1,415	1,490	1,380	1,210	1,570	1,460	1,300	1,260	1,560
11.5	1,440	1,160	1,025	1,075	1,450	1,500	1,400	1,245	1,620	1,480	1,320	1,290	1,590
12.0	1,440	1,190	1,075	1,130	1,490	1,520	1,425	1,285	1,660	1,485	1,345	1,320	1,635
12.5	1,430	1,225	1,115	1,170	1,530	1,540	1,450	1,315	1,695	1,500	1,360	1,350	1,660
13.0	1,420	1,245	1,155	1,210	1,565	1,465	1,470	1,340	1,730	1,460	1,375	1,380	1,695
13.5	1,450	1,265	1,190	1,235	1,595	1,425	1,485	1,365	1,740	1,415	1,395	1,400	1,705
14.0	1,460	1,290	1,220	1,270	1,615	1,400	1,485	1,390	1,740	1,395	1,405	1,415	1,705
14.5	1,460	1,305	1,250	1,295	1,645	1,360	1,480	1,405	1,720	1,360	1,410	1,430	1,690
15.0	1,455	1,320	1,275	1,325	1,675	1,350	1,470	1,415	1,710	1,340	1,425	1,435	1,685
15.5	1,505	1,340	1,300	1,355	1,700	1,320	1,460	1,425	1,690	1,325	1,425	1,440	1,675
16.0	1,425	1,350	1,315	1,380	1,720	1,305	1,450	1,430	1,675	1,300	1,425	1,442	1,660
16.5	1,375	1,370	1,340	1,405	1,735	1,285	1,440	1,440	1,655	1,295	1,427	1,445	1,645
17.0	1,360	1,435	1,420	1,490	1,800+	1,275	1,435	1,440	1,640	1,280	1,425	1,450	1,630

17.5...	1,340	1,415	1,395	1,470	1,765	1,270	1,420	1,440	1,625	1,275	1,420	1,445	1,620
18.0...	1,320	1,420	1,400	1,470	1,735	1,210	1,410	1,440	1,610	1,245	1,415	1,450	1,605
18.5...	1,300	1,415	1,405	1,480	1,715	1,185	1,400	1,440	1,595	1,210	1,410	1,450	1,590
19.0...	1,280	1,405	1,395	1,470	1,685	.....	.....	.....	.....	.....	.....	.....	.....
19.5...	1,260	1,395	1,395	1,465	1,660	1,155	1,375	1,435	1,565	1,175	1,400	1,435	1,565
20.0...	1,245	1,400	1,400	1,470	1,635	.....	.....	.....	.....	.....	.....	.....	.....
20.5...	1,240	1,395	1,400	1,470	1,635	1,100	1,310	1,400	1,500	1,130	1,380	1,420	1,510
21.0...	1,230	1,390	1,400	1,470	1,615	.....	.....	.....	.....	.....	.....	.....	.....
21.5...	.....	.....	.....	.....	.....	1,060	1,280	1,380	1,460	1,100	1,330	1,380	1,465
22.0...	1,200	1,380	1,400	1,465	1,590	.....	.....	.....	.....	.....	.....	.....	.....
22.5...	.....	.....	.....	.....	.....	1,060	1,230	1,350	1,410	985	1,290	1,340	1,405
23.0...	1,180	1,375	1,400	1,460	1,575	.....	.....	.....	.....	.....	.....	.....	.....
23.5...	.....	.....	.....	.....	.....	.....	1,200	1,325	1,375	.....	1,265	1,315	1,375
24.0...	1,155	1,350	1,395	1,450	1,535	.....	.....	.....	.....	.....	.....	.....	.....
25.0...	.....	.....	.....	.....	.....	.....	1,095	1,260	1,300	.....	1,195	1,250	1,300
25.25..	1,100	1,325	1,380	1,430	1,500	.....	.....	.....	.....	.....	.....	.....	.....
26.25..	1,090	1,310	1,370	1,420	1,470	.....	.....	.....	.....	.....	.....	.....	.....
27.25..	920	1,280	1,345	1,400	1,435	.....	.....	.....	.....	.....	.....	.....	.....
28.5...	880	1,245	1,320	1,370	1,390	.....	.....	.....	.....	.....	.....	.....	.....
29.5...	840	1,205	1,290	1,340	1,355	.....	855	1,025	1,085	.....	960	1,022	1,085
31.0...	.....	1,150	1,250	1,300	1,300	.....	.....	.....	.....	.....	.....	.....	.....
32.5...	.....	1,095	1,195	1,240	1,240	.....	.....	.....	.....	.....	.....	.....	.....
34.0...	.....	1,035	1,130	1,180	1,180	.....	.....	.....	.....	.....	.....	.....	.....
35.5...	.....	970	1,060	.....	1,100	.....	.....	.....	.....	.....	.....	.....	.....
37.0...	.....	900	990	.....	1,035	.....	.....	.....	.....	.....	.....	.....	.....
38.5...	.....	840	930	.....	970	.....	.....	.....	.....	.....	.....	.....	.....

[a] Lots shown in parentheses were stacked with lot shown immediately above which contained the thermocouple.

NOTE.—Dampers closed and fire cut off on furnaces 5 and 6 at 12.5 hours; on furnace 4 at 15.5 hours. Dampers raised on furnaces 5 and 6 at 17.5 hours; on furnace 4 at 20 hours. Doors opened 1 foot on furnaces 5 and 6 at 23 hours; on furnace 4 at 26.25 hours. Opened wide on furnace 4 at 34 hours. Boxes drawn from furnaces 5 and 6 at 30.5 hours and covers removed at 41 hours. Boxes drawn from furnace 4 at 39 hours and covers removed at once.

TABLE 75.—TEMPERATURES OF BLACK ANNEALING, 1919 EXPERIMENT.

Hours in furnace.	Thermocouple between—															
	R21 and CR21.	SR21 and SCR21.	T21 and CT21.	ST21 and SCT21.	R22 and CR22.	SR22 and SCR22.	T22 and CT22.	ST22 and SCT22.	R23 and CR23.	SR23 and SCR23.	T23 and CT23.	ST23 and SCT23.	R24 and CR24.	SR24 and SCR24.	T24 and CT24.	ST24 and SCT24.
	Deg. F.	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*
3.0....	205	305	205	316	205	264	205	276	335	205	317	205	279	239	320	233
3.5....	245	383	260	405	215	345	210	342	435	265	415	250	370	300	417	285
4.0....	295	455	320	475	290	410	255	400	535	330	515	320	445	355	490	335
4.5....	380	562	405	580	357	502	325	495	645	410	625	405	535	430	590	410
5.0....	452	655	485	668	425	590	385	585	737	485	690	485	620	495	667	476
5.5....	550	762	585	772	515	695	480	685	830	570	785	570	715	580	755	550
6.0....	615	825	645	835	580	755	530	750	890	630	815	625	770	630	810	606
6.5....	680	900	715	900	642	825	605	825	935	680	860	675	820	675	860	662
7.0....	745	950	775	950	705	887	663	885	985	735	925	735	880	735	915	715
7.5....	800	1,000	820	995	755	932	715	930	1,030	790	977	785	920	785	955	757
8.0....	845	1,042	865	1,030	797	965	755	968	1,070	845	1,030	840	960	835	1,000	808
8.5....	905	1,090	925	1,080	857	1,023	820	1,020	1,117	905	1,060	896	1,007	892	1,045	862
9.0....	947	1,122	962	1,115	900	1,058	868	1,058	1,145	943	1,082	935	1,040	928	1,070	900
9.5....	980	1,147	997	1,142	938	1,087	905	1,092	1,165	970	1,105	967	1,065	960	1,095	935
10.0....	1,018	1,173	1,030	1,162	973	1,115	945	1,120	1,185	1,008	1,152	1,000	1,095	993	1,120	965
10.5....	1,048	1,193	1,060	1,186	1,008	1,140	980	1,145	1,203	1,035	1,173	1,030	1,115	1,023	1,140	998
11.0....	1,075	1,210	1,086	1,200	1,037	1,160	1,012	1,165	1,217	1,063	1,182	1,053	1,135	1,045	1,155	1,023
11.5....	1,097	1,225	1,108	1,215	1,060	1,177	1,037	1,180	1,230	1,085	1,185	1,075	1,150	1,065	1,167	1,045
12.0....	1,122	1,242	1,130	1,232	1,086	1,193	1,065	1,196	1,240	1,103	1,193	1,095	1,162	1,090	1,180	1,065
12.5....	1,145	1,258	1,153	1,245	1,110	1,212	1,086	1,212	1,250	1,123	1,203	1,115	1,175	1,106	1,190	1,083
13.0....	1,165	1,273	1,173	1,260	1,130	1,228	1,110	1,227	1,260	1,142	1,217	1,132	1,186	1,126	1,205	1,103
13.5....	1,187	1,285	1,195	1,275	1,155	1,245	1,135	1,243	1,275	1,160	1,233	1,150	1,202	1,150	1,220	1,125
14.0....	1,200	1,295	1,210	1,286	1,170	1,255	1,152	1,255	1,283	1,180	1,235	1,170	1,215	1,160	1,230	1,140
14.5....	1,215	1,300	1,220	1,294	1,184	1,262	1,167	1,262	1,285	1,190	1,235	1,180	1,220	1,170	1,235	1,150
15.0....	1,223	1,303	1,230	1,300	1,193	1,265	1,180	1,270	1,288	1,195	1,235	1,188	1,228	1,177	1,238	1,155
15.5....	1,230	1,302	1,237	1,300	1,218	1,270	1,187	1,272	1,285	1,200	1,230	1,195	1,230	1,180	1,235	1,162
16.0....	1,235	1,305	1,245	1,305	1,210	1,270	1,195	1,280	1,290	1,208	1,225	1,200	1,233	1,185	1,238	1,168
16.5....	1,240	1,305	1,247	1,302	1,215	1,272	1,202	1,280	1,290	1,210	1,222	1,205	1,235	1,185	1,238	1,170
17.0....	1,245	1,303	1,247	1,300	1,215	1,268	1,205	1,277	1,280	1,210	1,217	1,205	1,230	1,187	1,235	1,172
17.5....	1,245	1,300	1,250	1,300	1,220	1,265	1,210	1,275	1,280	1,210	1,212	1,205	1,230	1,188	1,228	1,172

18.0....	1,247	1,300	1,252	1,300	1,220	1,265	1,212	1,275	1,275	1,212	1,210	1,207	1,227	1,190	1,225	1,173
18.5....	1,250	1,297	1,250	1,295	1,225	1,262	1,215	1,273	1,265	1,207	1,200	1,205	1,223	1,185	1,220	1,170
19.0....	1,247	1,295	1,250	1,293	1,222	1,256	1,215	1,267	1,255	1,205	1,192	1,200	1,216	1,180	1,212	1,167
19.5....	1,247	1,290	1,247	1,288	1,221	1,255	1,215	1,265	1,250	1,202	1,192	1,197	1,212	1,180	1,207	1,165
20.0....	1,246	1,281	1,246	1,283	1,220	1,250	1,215	1,260	1,242	1,196	1,182	1,194	1,205	1,174	1,198	1,160
20.5....	1,238	1,275	1,240	1,277	1,215	1,242	1,212	1,255	1,228	1,190	1,147	1,185	1,197	1,165	1,185	1,152
21.0....	1,230	1,260	1,230	1,265	1,210	1,230	1,205	1,245	1,210	1,175	1,115	1,173	1,183	1,150	1,170	1,140
21.5....	1,220	1,250	1,225	1,255	1,200	1,215	1,197	1,235	1,192	1,160	1,092	1,160	1,170	1,132	1,155	1,126
22.0....	1,205	.....	1,210	1,240	1,185	1,195	1,185	1,220	1,175	1,145	1,175	1,140	1,150	1,110	1,130	1,105
22.5....	1,190	1,215	1,195	1,225	1,175	1,180	1,170	1,202	1,150	1,126	1,135	1,122	1,133	1,090	1,110	1,085
23.0....	1,171	1,194	1,178	1,204	1,155	1,160	1,150	1,180	1,128	1,106	1,095	1,104	1,110	1,067	1,087	1,063
23.5....	1,155	1,175	1,160	1,185	1,133	1,138	1,130	1,157	1,105	1,085	1,067	1,080	1,090	1,045	1,065	1,040

NOTE.—Dampers closed on both furnaces at 13 hours. Doors opened 1 foot and draft started R21 to SCT22 at 19 hours; R23 to SCT24 at 19.5 hours. Doors opened wide at 20.5 hours. R21 to SCT22 taken from furnace at 23.5 hours. R23 to SCT24 taken from furnace at 24 hours.

TABLE 76.—CARBON CONTENT OF SHEETS AFTER BLACK ANNEALING, 1917 EXPERIMENT.

Sheets.	Carbon content after black annealing.			Carbon content, ladle analysis.
	Short edge.	Long edge.	Center.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
R1	0.05	0.05	0.11	0.11
R3	.04	.04	.12	.14
R4	.04	.11	.13	.12
R5	.05	.05	.08	.09
R6	.06	.05	.12	.14
R7	.04	.04	.11	.13
CR1	.....	.03	.10	.11
CR3	.02	.06	.14	.14
T1	.04	.05	.11	.15
T2	.06	.06	.10	.11
T3	.04	.03	.11	.10
T4	.05	.09	.14	.13
T5	.05	.11	.13	.15
T7	.04	.04	.12	.10
CT1	.03	.07	.11	.15
CT2	.06	.06	.12	.11
CT3	.02	.05	.09	.10
Average..	.043	.058	.114	.122

NOTE.—In order to show the effect of the black annealing on the carbon content, a number of sheets were analyzed in the steel mill laboratory for carbon after annealing. Three samples were taken for the carbon determination, one from the center, one from a long edge, and one from a short edge of the sheet. The results of the analyses are given in the table above, together with the amount of carbon reported for the analysis of the ladle sample for the heat from which each sheet was made.

TABLE 77.—TIME REQUIRED FOR OPENING AFTER BLACK ANNEALING, LOSSES IN OPENING, AND LOSSES IN COLD ROLLING, 1917 EXPERIMENT.

Sheets.	Time required for opening.[a]	Loss in opening.[b]	Weight, cold rolled.	Loss in cold rolling.
Regular.	*Hours.*	*Per cent.*	*Pounds.*	*Per cent.*
R1	7.5	0.4	3,826	0.6
CR1	7.0	.4	4,657	1.7
R2	7.0	.8	4,063	.8
CR2	10.5	.4	4,375	2.4
R3	17.5	5.4	4,235	1.1
CR3	5.0	.2	4,600	1.3
R4	5.0	.0	4,463	.1
R5	9.0	.7	4,181	1.2
R6	11.0	.4	4,258	.3
R7	13.5	2.3	4,345	2.2
Titanium-treated.				
T1	8.5	.0	4,512	.9
CT1	4.0	.4	4,888	1.5
T2	6.5	.6	4,832	.8
CT2	6.0	.0	5,214	1.3
T3	14.0	1.7	4,098	2.9
CT3	7.0	.0	4,302	2.4
T4	14.0	1.1	4,484	1.5
T5	7.0	1.0	4,699	2.1
T6	5.0	.2	4,596	.0
T7	12.0	.4	4,857	2.0

[a] These figures represent the time used (irrespective of the number of men) in opening each lot; they do not represent accurately the relative difficulty of opening because additional men worked on some lots which were harder to open.

[b] Per cent of loss in opening was computed on the basis of the weight after annealing.

TABLE 78.—TEMPERATURES OF WHITE ANNEALING, 1917 EXPERIMENT.

Hours in furnace.	Furnace 3; couple[a] in—			Furnace 4; couple[a] in—			Furnace 5; couple[a] in—		Furnace 6; couple[a] in—		Furnace 7; couple[a] in—	
	Door.	R2 (T5).	R3 (T4).	Door.	R4 (T6).	R1 (T2).	R6 (T1).	R5 (T7).	CT3 (CR3).	CT1 (CR2).	R7 (T3).	CT2 (CR1).
	Deg. F.	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*
2.0	920	.....	.....	860	.....	.....	.....	.....	.....	.....	200	.....
3.0	.....	.....	.....	.....	.....	.....	245	.....	275	200	260	.....
3.5	1,070	220	.....	1,000	245	.....	.....	.....	.....	.....	320	225
4.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	360	255
4.5	.....	.....	.....	.....	.....	.....	400	260	415	295	420	300
5.0	1,160	385	290	1,080	385	285	.....	.....	.....	.....	490	345
5.5	.....	.....	.....	.....	.....	.....	530	355	565	400	560	400
6.0	1,200	495	370	1,160	475	360	.....	.....	.....	.....	615	445
6.5	.....	.....	.....	.....	.....	.....	640	445	695	510	675	500
7.0	1,210	600	460	1,220	580	455	.....	.....	.....	.....	735	550
7.5	.....	.....	.....	.....	.....	.....	755	545	805	630	775	590
8.0	1,225	700	555	1,260	685	560	.....	.....	.....	.....	825	640
8.5	.....	.....	.....	.....	.....	.....	865	650	930	730	865	690
9.0	1,335	795	645	1,300	785	670	925	710	985	790	910	730
9.5	1,340	835	690	1,305	830	720	965	755	1,020	835	940	775
10.0	1,360	885	740	1,335	875	770	1,010	810	1,055	885	975	815
10.5	1,375	920	775	1,360	910	815	1,060	865	1,095	930	1,000	845
11.0	1,325	980	835	1,365	960	860	1,075	890	1,115	955	1,030	880
11.5	1,265	1,000	860	1,210	980	890	1,100	925	1,135	985	1,045	905
12.0	1,225	1,035	900	1,180	1,010	920	1,105	950	1,135	1,005	1,065	930
12.5	1,205	1,050	920	1,155	1,025	945	1,120	965	1,145	1,025	1,075	950
13.0	1,175	1,070	945	1,140	1,040	960	1,125	985	1,160	1,040	1,085	970
13.5	1,150	1,080	960	1,120	1,050	975	1,125	1,000	1,160	1,055	1,090	990
14.0	1,135	1,090	980	1,110	1,055	990	1,130	1,010	1,170	1,070	1,095	1,000
14.5	1,115	1,095	990	1,100	1,060	1,005	1,130	1,020	1,165	1,080	1,100	1,010
15.0	1,105	1,095	1,005	1,090	1,065	1,010	1,130	1,030	1,160	1,090	1,100	1,020
15.5	1,090	1,095	1,010	1,085	1,065	1,020	1,125	1,035	1,160	1,100	1,100	1,030
16.0	1,080	1,095	1,015	1,075	1,070	1,025	1,125	1,045	1,160	1,105	1,100	1,040
16.5	1,070	1,095	1,020	1,070	1,070	1,030	1,120	1,045	1,160	1,115	1,095	1,045
17.0	1,060	1,090	1,025	1,065	1,070	1,035	1,120	1,050	1,155	1,120	1,095	1,050

17.5	1,050	1,090	1,030	1,060	1,070	1,040	1,115	1,060	1,150	1,125	1,095	1,055
18.0	1,040	1,085	1,030	1,055	1,070	1,045	1,115	1,060	1,150	1,130	1,090	1,060
18.5	1,020	1,080	1,035	1,050	1,065	1,045	1,110	1,070	1,145	1,130	1,090	1,065
19.0	1,015	1,075	1,035	1,045	1,065	1,050	1,105	1,070	1,140	1,130	.....	.....
19.5	1,005	1,070	1,035	1,040	1,060	1,050	1,105	1,075	1,140	1,135	.....	.....
20.0	1,000	1,065	1,035	1,035	1,060	1,055	1,100	1,070	1,135	1,135	.....	.....
20.5	995	1,060	1,035	1,030	1,055	1,050	1,095	1,065	1,135	1,135	.....	.....
21.0	990	1,055	1,035	1,025	1,055	1,050	1,090	1,070	1,130	1,130	1,025	1,035
21.5	985	1,050	1,030	1,020	1,050	1,050	1,090	1,075	1,125	1,130	.....	.....
22.0	980	1,040	1,030	1,020	1,050	1,050	1,085	1,075	1,120	1,130	.....	.....
22.5	965	1,035	1,030	1,010	1,045	1,050	1,080	1,070	1,120	1,130	970	990
23.0	960	1,030	1,025	1,010	1,045	1,050	1,075	1,070	1,110	1,130	.....	.....
23.5	865	1,025	1,020	930	1,040	1,045	1,070	1,070	1,105	1,125	925	955
24.0	800	1,020	1,015	890	1,035	1,045	1,060	1,065	1,100	1,120	.....	.....
24.5	795	1,010	1,010	885	1,030	1,040	.....	.....	.....	.....	.....	.....
26.5	.....	.....	.....	.....	.....	.....	965	970	995	1,035	.....	.....
27.0	.....	925	930	.....	955	970	.....	.....	.....	.....	.....	.....
28.0	.....	.....	.....	.....	.....	.....	915	960	945	985	.....	.....
28.5	.....	875	885	.....	915	925	.....	.....	.....	.....	.....	.....
29.0	.....	.....	.....	.....	.....	.....	870	920	900	950	.....	.....
29.5	.....	830	850	.....	865	890	.....	.....	.....	.....	.....	.....

[a] Lots shown in parentheses were stacked with lot given immediately above which contained the thermocouple.

NOTE.—Fire cut off furnaces 3 and 4 at 10.5 hours; on furnaces 5, 6 and 7 at 10 hours. Dampers and doors opened on furnaces 3, 4, 5, and 6 at 23 hours; on furnace 7 at 19 hours. Boxes taken from furnaces 3 and 4 at 30 hours; from furnaces 5 and 6 at 29.5 hours; from furnace 7 at 24 hours. Covers removed 9.5 hours later from all boxes.

TABLE 79.—TEMPERATURES OF WHITE ANNEALING, 1919 EXPERIMENT.

Hours in furnace.	Thermocouple between—															
	R21 and CR21.	SR21 and SCR21.	T21 and CT21.	ST21 and SCT21.	R22 and CR22.	SR22 and SCR22.	T22 and CT22.	ST22 and SCT22.	R23 and CR23.	SR23 and SCR23.	T23 and CT23.	ST23 and SCT23.	R24 and CR24.	SR24 and SCR24.	T24 and CT24.	ST24 and SCT24.
	Deg. F.	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*
2.0....	.....	250	.....	235	210	240	210	280	225	.....	227	.....	220	.....	250	.....
2.5....	.....	297	212	282	232	282	237	322	275	.....	275	205	257	220	300	222
3.0....	235	355	250	345	270	335	280	385	340	230	335	240	315	255	360	260
3.5....	272	405	290	402	302	385	312	430	397	265	390	280	370	290	410	295
4.0....	308	452	328	455	340	430	345	480	455	305	440	320	420	323	462	330
4.5....	340	500	367	510	375	480	383	520	515	348	495	365	470	360	515	375
5.0....	377	545	410	555	410	525	420	570	565	390	550	410	520	402	560	410
5.5....	417	590	445	603	447	570	450	610	615	430	595	450	565	440	608	450
6.0....	455	640	490	650	488	610	495	655	660	475	645	495	610	480	645	490
6.5....	497	675	525	692	520	650	525	685	700	510	675	528	645	510	680	520
7.0....	530	715	565	730	555	685	560	720	740	545	710	565	680	540	715	555
7.5....	573	755	605	770	593	720	597	760	775	585	755	607	720	582	750	595
8.0....	613	796	642	810	630	757	635	800	790	625	795	646	753	615	793	635
8.5....	656	845	682	855	667	800	670	837	857	665	835	695	825	657	830	670
9.0....	680	870	715	885	695	825	700	865	885	690	865	715	825	685	860	700
9.5....	722	905	752	917	730	842	740	895	912	730	897	752	860	720	887	735
10.0....	767	937	790	950	762	890	770	925	940	762	920	785	885	752	913	767
10.5....	795	960	825	980	795	920	800	947	970	795	950	820	912	785	940	795
11.0....	825	985	852	1,000	820	938	825	965	987	820	975	845	935	813	960	823
11.5....	855	1,010	880	1,035	855	960	855	990	1,015	855	995	875	960	840	985	853
12.0....	885	1,035	905	1,048	875	980	885	1,020	1,030	875	1,020	897	975	866	1,005	875
12.5....	915	1,053	932	1,070	898	1,005	908	1,032	1,050	903	1,040	925	1,000	892	1,025	902
13.0....	937	1,074	955	1,085	920	1,024	928	1,050	1,070	925	1,056	945	1,020	915	1,043	924
13.5....	962	1,093	976	1,103	941	1,040	952	1,067	1,086	947	1,076	966	1,035	938	1,061	944
14.0....	990	1,112	1,003	1,120	967	1,057	973	1,088	1,103	970	1,097	990	1,055	962	1,080	967
14.5....	1,010	1,127	1,026	1,135	986	1,076	993	1,103	1,120	990	1,115	1,012	1,072	982	1,097	988
15.0....	1,033	1,145	1,043	1,153	1,006	1,090	1,017	1,121	1,135	1,008	1,128	1,030	1,090	1,004	1,112	1,007
15.5....	1,048	1,156	1,058	1,162	1,025	1,108	1,033	1,131	1,145	1,027	1,135	1,045	1,102	1,020	1,118	1,023
16.0....	1,065	1,162	1,073	1,172	1,038	1,117	1,045	1,133	1,150	1,038	1,143	1,055	1,108	1,033	1,123	1,032
16.5....	1,077	1,165	1,083	1,175	1,047	1,123	1,057	1,137	1,148	1,047	1,143	1,058	1,114	1,040	1,123	1,038

17.0....	1,086	1,165	1,090	1,177	1,057	.....	1,057	1,136	1,147	1,053	1,143	1,063	1,115	1,046	1,118	1,043
17.5....	1,093	1,165	1,095	1,177	1,062	1,127	1,060	1,132	1,143	1,057	1,140	1,067	1,112	1,050	1,116	1,044
18.0....	1,099	1,163	1,100	1,173	1,068	1,127	1,063	1,132	1,142	1,060	1,136	1,067	1,110	1,055	1,113	1,045
18.5....	1,102	1,163	1,102	1,170	1,071	1,126	1,065	1,130	1,136	1,064	1,130	1,070	1,109	1,056	1,110	1,047
19.5....	1,105	1,152	1,100	1,157	1,075	1,115	1,065	1,117	1,120	1,065	1,118	1,067	1,100	1,057	1,095	1,045
20.5....	1,106	1,144	1,100	1,148	1,070	1,107	1,064	1,110	1,106	1,060	1,105	1,062	1,086	1,055	1,082	1,038
21.5....	1,103	1,136	1,100	1,135	1,070	1,100	1,062	1,101	1,093	1,055	1,093	1,060	1,075	1,050	1,070	1,035
22.5....	1,101	1,122	1,090	1,125	1,065	1,089	1,056	1,089	1,077	1,048	1,080	1,050	1,064	1,045	1,053	1,027
23.5....	1,094	1,110	1,083	1,110	1,058	1,075	1,050	1,075	1,062	1,040	1,065	1,043	1,050	1,037	1,042	1,020
24.5....	1,085	1,096	1,075	1,094	1,048	1,062	1,040	1,064	1,043	1,027	1,047	1,030	1,034	1,025	1,026	1,006
25.5....	1,077	1,085	1,064	1,084	1,042	1,050	1,033	1,052	1,025	1,020	1,037	1,021	1,023	1,015	1,012	996
26.5....	1,065	1,068	1,053	1,067	1,033	1,038	1,025	1,040	1,014	1,007	1,020	1,010	1,010	1,005	995	980
27.5....	1,050	1,050	1,038	1,050	1,020	1,022	1,008	1,020	990	988	997	985	985	983	972	960
28.5....	1,025	1,020	1,013	1,023	997	996	980	985	960	960	965	955	955	955	943	933
29.5....	995	983	980	988	968	965	950	953	925	933	930	925	925	925	910	903

NOTE.—Dampers closed on both furnaces at 15 hours. Furnace doors opened 1 foot and flues opened at 25.5 hours. Doors opened wide and fan started at 27.5 hours. Boxes taken from furnaces 29.5 hours.

TABLE 80.—SPEED OF OPERATION AND PERIOD OF IMMERSION IN TINNING, 1917 EXPERIMENT.

Kind of pot.	Coating.	Number of sheets coated at once.	Number of sheets coated per minute.	Time required per sheet.		
				Entering tin.	Total immersion.	Discharge.
				Seconds.	*Seconds.*	*Seconds.*
Edwards	Coke	3	10 or 11	3	37 to 40	13
Do	Charcoal	1	7	4	20	5
Do	do	3	14	2.5	32	11
Anderson	Coke	3	10 or 11	3	9	13
Do	Charcoal	3	13	3	5	7
Combination, first	3A charcoal	1	7	3	8	2
Combination, last	do	1	7	1	7	2

NOTE.—In the combination pot, one second was consumed in passing a sheet from the first to the last pot, except for every eighth or ninth sheet, which was dipped in the middle pot, consuming 2 seconds instead of 1. The sheets were held about 10 seconds in racks before cleaning.

APPENDIX XIV.—ASSORTING OF TIN PLATE.

TABLE 81.—NUMBER OF PRIMES, WASTERS, AND MENDERS IN VARIOUS LOTS OF TIN PLATE, 1917 AND 1919 EXPERIMENTS.

1917 EXPERIMENT.

Regular steel.				Titanium-treated steel.			
Plate.	Primes.	Wasters.[a]	Menders except as noted.	Plate.	Primes.	Wasters.	Menders except as noted.
Large lots.[b]	*Number.*	*Number.*	*Number.*	*Large lots.*[b]	*Number.*	*Number.*	*Number.*
R1	415	409	[c] 5	T1	1,689	186	[c] 6
CR1	1,708	154	[c] 6	CT1	1,803	252	[c] 12
R2	1,344	236	[c] 0	T2	1,691	307	[c] 46
CR2	1,462	287	[c] 0	CT2	2,072	182	[c] 6
CR3	1,480	400	[c] 0	T3	1,288	206	[c] 5
R4	1,396	209	[c] 2	CT3	1,144	413	[c] 7
R5	1,439	177	[c] 30	T5	1,721	153	[c] 0
R6	1,374	170	[c] 3	T6	1,868	61	[c] 1
R7	1,403	297	[c] 6	T7	1,826	225	[c] 23
Quarter-ingot lots.				*Quarter-ingot lots.*			
AR3X	361	49	2	AT4X	356	52	37
ER3X	345	23	34	ET4X	369	34	71
AR3A	397	23	6	AT4A	396	37	0
SR3A	367	12	43	ST4A	357	21	92
Experimental lots.				*Experimental lots.*			
R1X	347	14	18	T1X	348	1	15
CR1X	341	16	20	CT1X	348	7	22
R2X	307	25	21	T2X	297	17	18
CR2X	295	25	20	CT2X	307	16	39
R3X	335	24	17	T3X	236	33	93
CR3X	261	11	87	CT3X	303	3	61
R4X	258	44	55	T4X	319	29	23
R5X	326	10	11	T5X	323	5	31
R6X	284	64	14	T6X	343	8	18
R7X	301	6	77	T7X	345	5	10
R1A	317	20	27	T1A	311	27	24
CR1A	317	26	8	CT1A	286	42	27
R2A	315	42	10	T2A	224	23	95
CR2A	307	34	1	CT2A	331	23	2
R3A	291	54	4	T3A	263	52	40
CR3A	351	8	14	CT3A	338	33	10
R4A	292	40	38	T4A	290	45	17
R5A	299	42	18	T5A	352	17	9
R6A	304	56	5	T6A	264	93	10
R7A	238	100	19	T7A	303	11	43

1919 EXPERIMENT.

R21	383	51	41	T21	410	27	34
CR21	339	98	44	CT21	426	8	22
SR21	444	32	31	ST21	305	63	138
SCR21	440	41	11	SCT21	302	45	116
R22	296	91	93	T22	279	131	76
CR22	255	123	98	CT22	315	88	78
SR22	218	91	189	ST22	287	200	20
SCR22	352	41	95	SCT22	182	207	79
R23	299	35	152	T23	263	39	140
CR23	422	57	27	CT23	383	26	43
SR23	438	25	26	ST23	382	9	73
SCR23	256	164	63	SCT23	408	6	71
R24	321	159	16	T24	216	204	49
CR24	415	57	8	CT24	389	35	72
SR24	86	373	39	ST24	352	65	51
SCR24	314	141	23	SCT24	270	137	76

[a] Includes one or two waste-wasters in few instances, except in "Large lots."
[b] Records corrected after retinning of menders.
[c] Waste-wasters.

TABLE 82.—NUMBER OF WASTERS DUE TO SPECIFIED CAUSES IN VARIOUS LOTS OF TIN PLATE, 1917 AND 1919 EXPERIMENTS.

1917 EXPERIMENT.

Regular steel.										Titanium-treated steel.									
Plate.	Number of wasters due to—								Total defects.	Plate.	Number of wasters due to—								Total defects.
	Blisters.	Bar scale.	Slivers and seams.	Hot mills.	Black pickle.	Anneal.	Cold rolls.	Tinning.			Blisters.	Bar scale.	Slivers and seams.	Hot mills.	Black pickle.	Anneal.	Cold rolls.	Tinning.	
Large lots.										*Large lots.*									
										T1	0	73	11	11	52	8	13	58	226
										CT1	0	54	0	2	168	9	5	43	281
										T2	1	19	0	1	0	2	3	30	56
R4	0	92	0	0	8	0	8	2	110	T3	0	45	0	0	30	0	4	89	168
R5	0	12	4	0	44	0	2	49	111	T5	0	36	2	0	4	1	8	7	58
										T6	0	23	0	0	8	0	10	14	55
R7	1	65	0	3	145	13	10	37	274	T7	0	52	0	0	7	0	4	50	113
Quarter-ingot lots.										*Quarter-ingot lots.*									
AR3X	0	3	0	0	32	1	8	5	49	AT3X	0	20	0	1	12	1	8	10	52
ER3X	0	6	0	0	3	6	5	2	22	ET4X	0	31	0	0	0	3	0	0	34
AR3A	0	10	0	0	8	0	2	3	23	\T4A	0	17	0	0	4	0	14	2	37
SR3A	0	0	0	0	0	5	1	6	12	ST4A	0	16	0	0	2	0	1	2	21
Experimental lots.										*Experimental lots.*									
R1X	0	4	0	1	5	1	0	3	14	T1X	0	0	0	0	0	0	0	1	1
CR1X	0	12	0	2	1	1	0	0	16	CT1X	0	5	0	0	1	1	0	0	7
R2X	0	19	0	3	0	0	2	1	25	T2X	0	12	0	1	0	0	4	0	17
CR2X	0	14	0	0	5	3	0	1	23	CT2X	0	12	0	1	1	0	2	0	16
R3X	0	4	0	0	3	8	7	2	24	T3X	0	14	0	3	16	0	0	0	33
CR3X	0	3	3	1	0	0	2	1	10	CT3X	0	1	0	0	1	0	1	0	3
R4X	0	38	0	1	2	2	0	1	44	T4X	0	21	0	0	0	0	8	0	29
R5X	0	7	0	0	0	1	1	1	10	T5X	0	4	0	0	0	0	1	0	5
R6X	25	27	0	3	1	2	3	3	64	T6X	0	2	0	0	0	0	1	4	7
R7X	0	4	1	0	0	0	0	1	6	T7X	0	0	3	1	0	0	1	0	5

R1A.....	0	5	0	1	2	2	2	8	20	T1A.....	0	3	0	0	7	0	9	8	27
CR1A.....	0	13	0	1	8	0	0	4	26	CT1A.....	0	1	0	0	34	4	1	2	42
R2A.....	0	38	0	0	0	0	1	3	42	T2A.....	0	7	0	0	6	0	0	10	23
CR2A.....	0	17	0	0	15	2	0	0	34	CT2A.....	0	9	1	4	9	0	0	0	23
R3A.....	0	21	1	2	8	0	11	11	54	T3A.....	0	26	0	0	22	0	3	0	51
CR3A.....	0	5	0	0	0	0	1	2	8	CT3A.....	0	19	0	0	5	0	6	3	33
R4A.....	0	17	0	0	20	0	3	0	40	T4A.....	0	36	0	0	0	0	1	8	45
R5A.....	1	9	0	8	8	0	4	12	42	T5A.....	0	5	0	0	3	0	3	6	17
R6A.....	6	32	0	0	18	0	0	0	56	T6A.....	1	14	0	0	45	1	5	27	93
R7A.....	0	12	0	0	21	0	4	61	98	T7A.....	0	6	0	0	1	0	1	3	11

1919 EXPERIMENT.

R21.....	6	5	4	14	10	1	31	4	75	T21.....	2	0	0	7	2	0	19	3	33
CR21.....	11	77	5	10	3	1	8	3	118	CT21.....	4	1	0	2	2	0	6	1	16
SR21.....	1	8	7	1	3	2	16	5	43	ST21.....	21	3	2	3	2	0	14	2	47
SCR21....	4	2	12	8	8	0	15	3	52	SCT21....	2	2	9	12	23	1	9	4	62
R22.....	32	1	11	6	3	0	1	71	125	T22.....	14	11	1	19	2	1	28	99	175
CR22.....	46	1	5	5	6	0	7	89	159	CT22.....	17	8	1	25	15	7	9	39	121
SR22.....	84	1	6	7	6	0	6	32	142	ST22.....	117	32	22	13	24	12	11	77	308
SCR22....	6	0	14	38	5	0	3	14	80	SCT22....	53	1	8	12	133	10	20	85	322
R23.....	1	0	1	8	8	0	10	13	41	T23.....	2	0	0	1	26	0	3	7	39
CR23.....	28	5	0	3	6	2	5	11	60	CT23.....	11	2	4	6	9	1	1	0	34
SR23.....	13	0	0	1	6	1	3	2	26	ST23.....	0	1	0	0	5	2	2	0	10
SCR23....	126	7	4	4	10	1	11	3	166	SCT23....	0	1	0	0	5	0	0	0	6
R24.....	5	44	2	34	37	1	34	28	185	T24.....	94	107	0	13	44	3	7	15	283
CR24.....	4	6	0	9	17	15	13	14	78	CT24.....	11	4	1	3	10	0	6	4	39
SR24.....	367	17	0	1	64	4	18	6	477	ST24.....	29	0	0	21	7	1	7	11	76
SCR24....	102	16	3	21	16	8	19	2	187	SCT24....	85	1	5	23	33	1	16	10	174

NOTE.—Steel defects are included under blisters, bar scale, slivers and seams. The numbers in the 1919 experiment and in the large lots of 1917 refer to defects rather than sheets, so that the total defects for any one of these lots in this table may be larger then the total number of wasters as given in the preceding table for the same lot.

APPENDIX XV.—WEIGHT OF TIN COATING ON TIN PLATE OF 1917 EXPERIMENT.

Each diagram represents a piece of tinplate approximately 19″ × 29″. Each subdivision represents a body blank for a can, the figure in the subdivision being the weight of tin coating in pounds per base box (112 sheets, 24″ × 20″) as determined by the analysis of 4 square inches of plate from the center of the blank.

CR2A

3.38	3.21	3.06	3.17	3.05	2.89
2.27	2.25	1.89	2.27	1.99	2.31
2.03	2.09	1.96	2.15	1.85	2.17
1.87	1.99	2.16	2.09	2.01	2.16
1.97	2.07	2.06	2.13	2.08	2.02
2.37	2.19	2.30	2.40	2.37	2.40

AVE. 2.31 AVE. 2.30 AVE. 2.37

3.2	2.69	3.2	2.69								
2.03	2.71	2.03	2.71								
1.91	2.16	1.91	2.16								
2.15	1.97	2.15	1.97								
2.05	2.03	2.05	2.03								
3.10	2.26	3.10	2.26								

AVE. 2.35

CR2X

1.61	1.81	1.49	1.62	1.65	1.75
1.72	1.62	1.48	1.57	1.93	1.65
1.56	1.61	1.34	1.54	1.45	1.56
1.53	1.55	1.39	1.54	1.44	1.51
1.50	1.55	1.50	1.48	2.51	1.54
1.56	1.79	1.63	1.69	1.57	1.53

AVE. 1.61 AVE. 1.52 AVE. 1.59

2.30	1.81	2.30	1.81								
1.62	1.62	1.62	1.62								
1.71	1.55	1.71	1.55								
1.60	1.55	1.60	1.55								
1.57	1.46	1.57	1.46								
1.89	1.47	1.89	1.47								

AVE. 1.68

R2A

1.88	2.78	1.63	1.94	3.50	3.10
1.50	1.88	1.56	1.91	2.40	2.37
1.54	1.75	1.62	1.84	2.16	1.99
1.84	1.76	1.80	1.89	2.28	1.92
1.95	1.84	1.86	1.82	2.37	1.85
2.00	1.92	1.97	2.06	2.28	2.11

AVE. 1.89 AVE. 1.82 AVE. 2.36

2.13	1.79	2.13	1.79								
1.65	1.95	1.65	1.95								
2.77	1.85	2.77	1.85								
1.71	1.75	1.71	1.75								
2.07	1.93	2.07	1.93								
2.08	1.62	2.08	1.62								

AVE. 1.95

R2X

1.38	1.47	1.61	1.38	1.34	1.37
1.34	1.23	1.57	1.45	1.23	1.35
1.34	1.19	1.43	1.41	1.41	1.42
1.32	1.25	1.35	1.36	1.23	1.50
1.34	1.17	1.36	1.25	1.25	1.23
1.40	1.29	1.41	1.39	1.39	1.27

AVE. 1.31 AVE. 1.41 AVE. 1.34

1.59	1.66	1.59	1.66								
1.47	1.89	1.47	1.89								
1.29	1.40	1.29	1.40								
1.40	1.34	1.40	1.34								
1.39	1.33	1.39	1.33								
1.42	1.43	1.42	1.43								

AVE. 1.43

CT1A

3.0	3.15	2.89	2.81	2.03	2.97
1.75	2.31	1.87	2.25	1.86	2.23
1.71	2.17	2.19	2.16	1.67	1.99
1.71	1.97	1.83	2.15	1.69	1.95
1.85	1.93	1.93	2.09	1.86	1.96
2.05	1.99	2.24	1.76	2.02	2.37

AVE. 2.14 AVE. 2.18 AVE. 2.05

2.72	2.78	2.72	2.78								
1.94	2.57	1.94	2.57								
1.83	2.10	1.83	2.10								
1.73	2.22	1.73	2.22								
2.05	2.26	2.05	2.26								
2.09	3.07	2.09	3.07								

AVE. 2.28

CT1X

1.55	1.61	1.71	1.70	1.70	1.74
1.78	1.50	1.61	1.52	1.51	1.65
1.55	1.53	1.59	1.59	1.62	1.64
1.66	1.53	1.69	1.73	1.73	1.62
1.46	1.71	1.70	1.68	1.74	1.76
1.96	2.05	1.63	2.04	1.91	2.05

AVE. 1.66 AVE. 1.68 AVE. 1.73

1.60	1.75	1.60	1.75								
1.51	1.44	1.51	1.44								
1.57	1.53	1.57	1.53								
1.70	1.56	1.70	1.56								
1.86	1.63	1.86	1.63								
2.07	1.84	2.07	1.84								

AVE. 1.67

T1A

2.11	2.16	3.21	2.85	2.21	1.71
1.93	2.34	2.49	1.91	2.51	1.76
2.01	2.04	2.53	1.76	2.12	1.69
1.81	1.91	2.10	1.75	2.06	1.71
1.90	1.80	2.13	1.87	2.17	1.65
2.32	2.27	2.21	1.85	3.05	2.05

AVE. 2.05 AVE. 2.22 AVE. 2.06

1.77	2.12	1.77	2.12								
1.52	1.97	1.52	1.97								
1.57	1.86	1.57	1.86								
1.74	1.70	1.74	1.70								
1.80	1.76	1.80	1.76								
2.78	1.97	2.78	1.97								

AVE. 1.87

T1X

1.33	1.24	1.56	1.53	1.52	1.47
1.32	1.17	1.44	1.62	1.38	1.39
1.41	1.18	1.37	1.57	1.36	1.38
1.38	1.20	1.42	1.34	1.39	1.29
1.34	1.21	1.31	1.25	1.26	1.34
1.29	1.43	1.43	1.32	1.48	1.37

AVE. 1.29 AVE. 1.43 AVE. 1.39

1.19	1.29	1.19	1.29								
1.18	1.17	1.18	1.17								
1.22	1.14	1.22	1.14								
1.30	1.16	1.30	1.16								
1.35	1.23	1.35	1.23								
1.26	1.30	1.26	1.30								

AVE. 1.23

CR1A

2.28	2.27	3.06	3.17	3.05	2.89
2.06	2.01	1.89	2.27	1.99	2.31
1.95	1.88	1.96	2.15	1.85	2.17
1.97	1.77	2.16	2.09	2.01	2.16
2.24	1.92	2.06	2.13	2.08	2.02
2.41	3.23	2.30	2.40	2.37	2.40

AVE. 2.16 AVE. 2.30 AVE. 2.37

3.2	2.69	3.2	2.69								
2.03	2.71	2.03	2.71								
1.91	2.16	1.91	2.16								
2.15	1.97	2.15	1.97								
2.05	2.03	2.05	2.03								
3.10	2.26	3.10	2.26								

AVE. 2.35

CR1X

1.81	1.90	1.99	2.22	1.62	1.63
1.55	1.75	1.95	1.99	1.46	1.45
1.68	1.68	2.05	1.81	1.46	1.39
1.75	1.61	2.18	1.71	1.42	1.34
1.67	1.59	2.01	1.91	1.53	1.47
1.90	1.55	2.91	3.19	1.58	1.73

AVE. 1.70 AVE. 2.16 AVE. 1.51

2.08	1.99	2.08	1.99								
1.59	1.71	1.59	1.71								
1.61	1.58	1.61	1.58								
1.70	1.53	1.70	1.53								
1.84	1.65	1.84	1.65								
2.06	1.80	2.06	1.80								

AVE. 1.75

R1A

2.29	2.84	2.41	3.03	3.01	2.51
1.84	2.27	1.85	2.17	2.63	2.19
2.43	—	2.75	2.22	2.75	2.38
2.06	1.91	1.89	2.15	2.76	2.38
2.13	2.24	2.04	2.17	2.61	2.61
2.27	2.21	2.21	2.27	2.74	2.69

AVE. 2.22 AVE. 2.27 AVE. 2.59

1.58	1.61	1.58	1.61								
1.37	1.65	1.37	1.65								
1.35	1.44	1.35	1.44								
1.41	1.50	1.41	1.50								
1.58	1.45	1.58	1.45								
1.52	1.63	1.52	1.63								

AVE. 1.51

R1X

1.46	1.52	1.45	1.67	1.61	1.50
1.36	1.79	1.37	1.45	1.42	1.53
1.44	1.46	1.44	1.41	1.46	1.42
1.43	1.37	1.49	1.40	1.50	1.41
1.41	1.34	1.42	1.71	1.56	1.50
1.46	1.36	1.50	1.51	1.38	1.47

AVE. 1.45 AVE. 1.49 AVE. 1.48

1.49	1.49	1.49	1.49								
1.36	1.38	1.36	1.38								
1.30	1.31	1.30	1.31								
1.23	1.22	1.23	1.22								
1.17	1.19	1.17	1.19								
1.33	1.21	1.33	1.21								

AVE. 1.31 AVE. 1.31 AVE. 1.31

T2X		T2A		CT2X		CT2A		R3X		R3A		CR3X		CR3A		T3X		T3A		CT3X		CT3A	
1.62	1.65	2.96	2.53	1.53	1.65	3.30	3.75	1.53	1.87	2.10	2.12	1.57	1.71	2.53	2.24	1.46	1.49	3.17	2.95	1.65	1.82	1.66	1.96
1.43	1.46	3.07	2.05	1.40	1.64	1.97	2.34	1.46	1.55	1.91	2.28	1.46	1.45	2.36	2.21	1.30	1.51	1.88	2.27	1.58	1.63	1.77	1.92
1.37	1.47	2.43	2.11	1.43	1.20	2.02	2.21	1.41	1.51	1.93	2.02	1.65	1.39	2.29	2.04	1.39	1.33	1.66	2.01	1.51	1.54	1.76	1.94
1.32	1.45	2.41	2.25	1.44	1.50	2.05	2.02	1.44	1.47	1.96	1.79	1.49	1.49	2.36	2.01	1.32	1.32	1.71	2.04	1.48	1.49	1.81	1.99
1.31	1.42	2.45	2.47	1.46	1.39	2.18	2.19	1.53	1.46	2.05	1.66	1.38	1.44	2.62	2.31	1.36	1.38	1.87	2.02	1.61	1.57	2.01	1.87
1.42	1.45	2.22	2.51	1.66	1.52	2.40	2.25	1.60	1.48	2.81	1.92	1.65	1.82	3.49	3.55	1.42	1.27	2.31	2.48	1.81	2.11	2.18	2.20
AVE. 1.45		AVE. 2.46		AVE. 1.48		AVE. 2.38		AVE. 1.53		AVE. 2.05		AVE. 1.54		AVE. 2.50		AVE. 1.38		AVE. 2.19		AVE. 1.66		AVE. 1.92	
1.59	1.53	1.99	1.96	1.74	1.77	3.15	3.43	1.48	1.59	2.44	2.18	1.53	2.09	2.15	2.34	1.40	1.56	2.95	2.94	1.53	1.64	1.55	2.01
1.34	1.42	1.71	1.85	1.52	1.60	2.19	2.55	1.45	1.58	2.24	2.26	1.41	1.73	1.81	2.31	1.29	1.38	1.67	2.03	1.51	1.53	1.86	2.05
1.39	1.41	1.65	1.86	1.55	1.62	2.08	2.37	1.40	1.50	2.06	2.21	1.35	1.55	1.93	1.89	1.33	1.34	1.64	1.96	1.49	1.51	1.81	1.96
1.41	1.46	1.87	1.91	1.62	1.64	2.02	2.36	1.43	1.47	2.05	2.16	1.51	1.50	1.92	1.81	1.29	1.29	1.73	1.99	1.42	1.47	1.56	1.85
1.45	1.48	2.85	1.94	1.70	1.70	2.28	2.67	1.41	1.51	2.28	2.36	1.36	1.32	1.95	1.90	1.33	1.25	1.90	1.97	1.53	1.58	2.15	1.91
1.46	1.49	2.15	2.08	1.85	2.00	2.41	2.73	1.50	1.46	3.12	3.61	1.63	1.47	2.36	1.79	1.36	1.21	2.29	2.33	1.86	1.74	2.09	2.01
AVE. 1.45		AVE. 1.99		AVE. 1.69		AVE. 2.52		AVE. 1.48		AVE. 2.42		AVE. 1.54		AVE. 2.01		AVE. 1.33		AVE. 2.12		AVE. 1.57		AVE. 1.90	
1.44	1.54	1.35	1.97	1.61	2.10	3.34	3.41	1.59	1.67	2.53	2.29	1.60	1.92	2.30	2.36	1.45	1.50	2.91	3.02	1.65	1.71	3.23	3.49
1.36	1.43	1.39	1.77	1.45	1.76	2.20	2.58	1.47	1.47	2.22	2.20	1.49	1.65	2.09	2.20	1.32	1.41	1.79	2.21	1.48	1.67	3.06	2.68
1.31	1.50	1.47	1.75	1.50	1.53	2.26	2.52	1.38	1.51	2.24	2.01	1.54	1.64	1.96	2.02	1.26	1.29	1.72	2.07	1.50	1.59	3.10	2.56
1.32	1.39	1.68	1.69	1.52	1.45	2.41	2.33	1.36	1.58	2.20	2.00	1.52	1.56	2.01	2.00	1.28	1.26	1.83	2.11	1.62	1.66	2.64	2.45
1.29	1.33	1.77	1.85	1.56	1.52	2.45	2.73	1.38	1.46	2.29	1.85	1.54	1.37	2.45	1.89	1.26	1.28	1.84	2.03	1.51	1.64	2.60	2.67
1.38	1.42	1.92	1.97	1.69	1.65	2.46	2.74	1.41	1.46	2.95	2.37	1.71	1.84	2.51	2.23	1.28	1.29	2.46	2.16	2.07	2.06	2.22	2.71
AVE. 1.40		AVE. 1.72		AVE. 1.62		AVE. 2.62		AVE. 1.49		AVE. 2.26		AVE. 1.62		AVE. 2.16		AVE. 1.32		AVE. 2.18		AVE. 1.68		AVE. 2.78	
1.32	1.54	2.98	3.05	1.50	1.62	2.16	3.70	1.69	1.72	2.41	2.13	1.59	1.95	3.46	2.82	1.53	1.57	2.28	2.98	1.81	1.66	2.16	2.97
1.27	1.44	2.54	2.13	1.46	1.64	2.13	2.41	1.44	1.57	2.13	2.01	1.41	1.74	2.82	2.32	1.31	1.34	1.71	2.17	1.65	1.71	2.31	2.26
1.34	1.38	2.56	2.01	1.53	1.52	3.61	2.23	1.46	1.49	1.96	2.03	1.40	1.66	2.48	2.60	1.37	1.40	1.92	2.01	1.61	1.79	1.87	2.17
1.44	1.43	2.26	2.01	1.48	1.55	2.22	2.61	1.42	1.48	2.19	1.94	1.45	1.45	2.79	2.49	1.37	1.29	2.01	2.10	1.80	1.76	1.97	2.08
1.46	1.40	2.31	2.20	1.56	1.51	2.61	2.40	1.50	1.40	1.98	1.76	1.50	1.33	2.64	2.75	1.43	1.37	2.16	1.87	1.69	1.83	2.05	2.11
1.42	1.47	2.29	2.25	1.66	1.52	2.59	2.96	1.55	1.48	2.01	1.92	1.62	1.56	3.42	3.43	1.45	1.31	1.91	2.92	2.00	2.27	2.25	2.31
AVE. 1.41		AVE. 2.38		AVE. 1.55		AVE. 2.64		AVE. 1.52		AVE. 2.04		AVE. 1.56		AVE. 2.83		AVE. 1.41		AVE. 2.17		AVE. 1.79		AVE. 2.22	

R4X	R4A	T4X	T4A	R5X	R5A	T5X	T5A	R6X	R6A	T6X	T6A
1.78 1.66	2.02 2.20	1.62 1.41	1.57 2.26	1.42 1.38	1.94 2.30	1.27 1.25	1.85 2.05	1.75 1.53	1.61 1.97	.92 .40	1.99 1.74
1.66 1.64	1.81 2.07	1.45 1.43	1.59 2.04	1.34 1.41	1.97 2.14	1.29 1.36	1.82 1.92	1.54 1.32	1.46 1.89	1.05 .50	1.88 1.80
1.63 1.55	1.84 2.05	1.38 1.23	1.78 1.86	1.30 1.30	1.80 1.97	1.37 1.21	1.72 1.85	1.41 1.20	1.57 1.75	.96 .64	1.82 1.91
1.65 1.64	2.03 1.91	1.45 1.25	2.03 1.85	1.21 1.26	1.78 1.86	1.31 1.26	1.70 1.81	1.39 1.23	1.70 1.80	.54 .57	1.90 1.69
1.48 1.71	1.94 1.88	1.47 1.37	2.17 2.02	1.33 1.21	1.79 1.89	1.38 1.22	1.85 1.76	1.46 1.29	1.82 2.02	1.22 .73	2.22 1.72
2.24 1.69	2.12 3.07	1.53 1.47	2.36 2.28	1.36 1.30	2.24 2.23	1.39 1.25	1.93 2.08	1.44 1.37	1.91 1.83	1.35 1.15	2.73 2.53
AVE. 1.70	AVE. 2.04	AVE. 1.42	AVE. 1.98	AVE. 1.32	AVE. 1.98	AVE. 1.29	AVE. 1.86	AVE. 1.42	AVE. 1.78	AVE. .84	AVE. 1.99
1.49 1.50	2.58 2.13	1.58 1.63	1.88 2.40	1.50 1.42	2.50 2.20	1.18 1.24	2.61 2.27	1.96 1.44	3.55 2.96	1.35 1.02	1.92 1.98
1.46 1.48	2.05 2.11	1.48 1.62	1.77 2.15	1.33 1.25	2.29 2.08	1.14 1.16	2.35 2.12	1.68 1.46	2.73 2.21	1.19 .85	2.36 1.92
1.44 1.54	3.06 2.01	1.51 1.47	2.01 2.05	1.32 1.34	2.32 2.00	1.17 1.19	2.21 2.03	1.53 1.47	2.61 2.17	1.13 .81	2.71 1.76
1.52 1.47	1.94 2.08	1.71 1.52	2.39 2.02	1.36 1.28	2.38 2.12	1.21 1.15	2.24 3.44	1.62 1.46	2.49 2.19	1.31 .66	2.06 1.77
1.55 1.51	1.89 1.98	1.67 1.54	2.38 2.19	1.29 1.24	2.47 2.29	1.24 1.17	2.31 2.41	1.63 1.44	2.47 2.50	1.44 .71	2.12 1.76
1.57 1.64	2.04 1.87	1.43 1.64	2.41 2.37	1.49 1.38	3.04 3.19	1.40 1.16	3.21 1.98	1.66 1.51	2.53 2.85	1.52 1.32	2.69 2.56
AVE. 1.51	AVE. 2.15	AVE. 1.57	AVE. 2.17	AVE. 1.35	AVE. 2.41	AVE. 1.20	AVE. 2.43	AVE. 1.57	AVE. 2.60	AVE. 1.11	AVE. 2.15
1.54 1.54	2.32 1.86	1.61 1.71	3.53 3.36	1.63 1.34	2.49 2.16	1.57 1.53	1.83 2.25	1.27 1.47	3.41 2.91	1.89 1.49	2.01 2.13
1.41 1.47	2.10 1.97	1.65 1.73	2.59 2.57	1.19 1.21	2.40 2.06	1.39 1.42	2.07 2.19	1.22 1.44	2.31 2.26	1.45 1.58	1.97 1.79
1.43 1.45	1.93 1.98	1.53 1.59	2.03 2.19	1.18 1.06	2.38 2.14	1.50 1.35	1.73 1.87	1.27 1.27	2.22 2.08	1.37 1.51	1.91 1.70
1.47 1.41	2.98 1.88	1.60 1.61	2.01 2.02	1.26 1.14	2.41 2.06	1.44 1.30	1.71 1.74	1.31 1.34	2.29 1.99	1.39 1.34	2.10 1.74
1.50 1.73	1.86 1.86	1.81 1.97	2.05 2.26	1.32 1.12	2.64 2.57	1.47 1.36	1.81 1.64	1.42 1.38	2.17 2.18	1.45 1.34	1.66 1.77
1.57 1.52	2.04 2.23	1.61 1.56	2.21 2.27	1.41 1.32	2.59 3.01	1.46 1.26	2.15 1.54	1.46 1.40	3.01 2.36	1.57 1.51	2.27 2.49
AVE. 1.50	AVE. 2.09	AVE. 1.66	AVE. 2.43	AVE. 1.27	AVE. 2.42	AVE. 1.42	AVE. 1.89	AVE 1.35	AVE. 2.43	AVE. 1.50	AVE. 1.96
1.76 1.59	2.34 1.84	1.35 1.37	3.48 3.54	1.62 1.33	2.39 2.42	1.43 1.62	1.79 2.14	1.52 1.42	3.61 3.05	1.62 1.45	2.16 2.09
1.55 1.54	1.95 2.15	1.31 1.47	2.19 2.31	1.40 1.28	2.21 2.13	1.28 1.31	1.90 2.02	1.49 1.41	1.83 2.03	1.51 1.36	2.08 1.96
1.48 1.51	1.82 2.07	1.37 1.31	2.21 2.09	1.34 1.25	1.83 1.89	1.31 1.40	2.10 1.90	1.51 1.45	1.76 2.05	1.41 1.28	1.98 1.82
1.40 1.44	1.68 1.90	1.39 1.21	2.13 2.18	1.25 1.22	1.73 1.82	1.34 1.32	1.85 1.86	1.51 1.41	1.85 1.93	1.44 1.28	1.88 1.69
1.24 1.41	1.77 1.85	1.41 1.25	2.19 1.88	1.29 1.24	2.03 1.75	1.33 1.39	1.81 1.73	1.43 1.47	1.98 1.96	1.39 1.26	2.22 1.68
1.28 1.49	2.00 3.06	1.25 1.33	2.07 2.35	1.40 1.22	2.31 1.45	1.41 1.42	2.01 2.05	1.39 1.50	1.96 2.11	1.56 1.37	2.04 2.52
AVE 1.50	AVE. 204	AVE. 1.34	AVE. 2.38	AVE. 1.32	AVE. 1.98	AVE. 1.38	AVE. 1.93	AVE. 1.46	AVE. 2.18	AVE. 1.42	AVE. 2.01

R7X				R7A				T7X				T7A				HIX				HIA				CHIX				CHIA				H2X				H2A				CH2X				CH2A			
1.54	2.15			2.11	2.34			1.54	1.47			3.22	2.76			1.29	1.61			2.58	2.53			1.36	1.55			3.19	3.39			1.26	1.41			3.02	3.01							2.19	2.29
1.36	1.67			1.97	2.22			1.40	1.41			2.53	2.40			1.43	1.34			2.66	2.34			1.42	1.34			2.86	3.86			1.58	1.51			2.79	3.26							2.14	2.72
1.40	1.43			1.81	2.12			1.27	1.36			2.21	1.99			1.39	1.33			2.33	2.07			1.40	1.38			2.89	3.71			1.80	1.61			2.71	2.23							2.67	2.41
1.49	1.50			1.94	2.24			1.26	1.24			2.23	1.97			1.31	1.31			2.15	1.96			1.40	1.34			2.76	3.75			1.46	1.46			2.80	3.07							2.31	2.30
1.49	1.53			2.04	2.37			1.33	1.22			2.34	2.21			1.33	1.34			2.32	2.04			1.51	1.36			2.95	3.67			1.71	1.66			2.65	2.85							2.52	2.16
1.52	1.59			2.69	2.70			1.29	1.23			2.57	2.22			1.44	1.46			2.26	1.95			1.53	1.42			3.01	3.00			1.27	1.61			2.69	2.83							2.48	2.28

AVE: 1.39				AVE: 1.89				AVE: 1.47				AVE: 2.40				AVE: 1.53				AVE: 2.21				AVE: 1.21				AVE: 3.46				AVE: 3.02								AVE: 2.33			
1.43	1.59			2.01	2.21			1.61	1.48			1.65	1.98			1.78	1.69			2.43	2.74			1.55	1.76			2.88	2.92			1.31	1.23			4.07	4.38							2.49	2.57
1.24	1.42			1.89	2.31			1.45	1.47			1.53	1.86			1.36	1.21			2.29	2.36			1.65	1.65			3.51	2.77			1.14	1.31			4.12	4.19							2.38	2.84
1.30	1.27			1.87	2.07			1.36	1.44			1.74	1.79			.98	1.37			2.05	1.99			1.62	1.73			2.71	3.16			1.03	1.13			3.85	4.03							2.51	2.55
1.35	1.26			1.92	2.19			1.29	1.37			1.83	1.82			1.52	1.29			2.15	1.88			1.50	1.68			2.68	3.33			1.06	1.11			3.00	3.89							2.35	2.08
1.42	1.28			2.01	2.32			1.32	1.29			2.03	2.05			1.61	1.49			2.30	2.03			1.62	1.67			2.71	3.27			1.02	1.15			3.06	3.91							2.06	1.99
1.51	1.41			2.03	2.59			1.30	1.27			2.22	2.37			1.67	1.59			2.28	1.78			1.43	1.61			2.46	2.94			1.07	1.34			2.87	3.25							2.16	2.08

AVE: 1.38				AVE: 1.71				AVE: 1.48				AVE: 2.00				AVE: 1.43				AVE: 2.39				AVE: 1.64				AVE: 3.29				AVE: 1.56				AVE: 2.93								AVE: 3.05			
1.50	1.65			1.92	2.19			2.02	1.53			1.99	2.46			1.39	1.57			2.75	2.52			1.51	1.54			3.46	3.45			1.61	1.51			4.09	2.94							2.32	3.23
1.36	1.30			1.63	1.78			1.49	1.41			1.66	2.01			1.42	1.47			2.42	2.38			1.70	1.52			3.56	3.58			1.52	1.53			3.55	3.34							2.86	3.30
1.35	1.40			1.64	1.63			1.53	1.43			1.74	1.96			1.49	1.41			2.29	2.29			1.71	1.55			2.87	3.71			1.57	1.57			3.30	2.80							3.06	3.28
1.34	1.34			1.72	1.48			1.47	1.40			1.97	1.89			1.38	1.47			2.21	2.26			1.72	1.63			2.74	3.42			1.39	1.50			3.19	2.51							3.03	3.37
1.40	1.26			1.77	1.44			1.42	1.32			1.99	2.04			1.36	1.49			2.45	2.34			1.72	1.71			2.69	3.83			1.46	1.52			2.13	2.25							3.21	2.85
1.27	1.38			1.95	1.33			1.43	1.27			2.13	2.16			1.38	1.58			2.49	2.27			1.70	1.68			2.84	3.38			1.31	1.63			2.54	2.44							3.29	2.66

H3X	H3A	CH3X	H4X	CH4'Z	BIX	BIA	CBIX	CBIA	B2X	B2A	CB2X
	2.94 3.56	1.59 1.41	1.12 1.11	2.47 2.80		2.34 2.61	1.68 1.53	1.86 2.44	1.03 1.42	2.94 3.06	1.46 1.28
	3.19 3.08	1.63 1.46	1.28 1.16	3.39 2.65		2.35 2.63	1.69 1.86	1.83 2.43	1.19 1.19	2.87 2.95	1.26 1.31
	3.33 4.16	1.65 1.62	1.22 1.04	3.80 3.34		2.44 2.60	2.05 1.77	1.97 2.22	.97 1.09	2.71 2.30	1.28 1.22
	3.90 4.50	1.61 1.52	1.31 1.02	3.87 3.32		2.49 2.76	1.61 1.51	2.09 1.94	1.03 1.02	2.96 2.43	1.30 1.29
	3.65 4.45	1.46 1.47	1.29 1.16	3.62 3.31		2.56 2.95	1.77 1.57	2.28 1.99	1.17 1.11	3.22 3.38	1.34 1.27
	3.45 4.03	1.35 1.50	1.41 1.21	3.58 3.83		2.51 2.73	2.19 3.12	2.25 2.25	1.21 .92	3.08 3.59	1.24 1.38
	AVE. 3.69	AVE. 1.61	AVE. 1.19	AVE. 3.33		AVE. 2.58	AVE. 1.86	AVE. 2.11	AVE. 1.11	AVE. 2.96	AVE. 1.30
	2.97 3.06	1.64 1.45	1.26 1.24	2.62 2.87		2.33 2.66	1.41 1.34	1.71 2.10	1.31 1.31	3.51 3.16	1.14 1.09
	2.96 2.75	1.58 1.63	1.18 1.08	2.86 3.22		2.31 2.62	1.22 1.21	1.79 2.09	1.27 1.13	3.29 3.38	1.09 1.15
	4.23 3.50	1.93 1.83	1.29 1.14	3.16 3.53		2.40 2.75	1.17 1.19	1.99 1.96	1.29 1.43	2.69 3.14	1.21 1.23
	4.45 4.05	1.69 1.51	1.25 1.06	2.97 3.64		2.74 2.78	1.33 1.29	2.17 2.12	1.26 1.34	2.64 3.16	1.31 1.24
	4.57 4.19	1.71 1.59	1.31 1.15	2.41 3.87		2.78 3.15	1.27 1.23	2.51 2.09	1.22 1.18	3.15 3.54	1.24 1.26
	4.73 3.93	1.60 1.61	1.38 1.21	2.43 4.16		2.65 2.87	1.39 1.26	2.55 2.33	1.21 1.02	2.61 3.86	1.17 1.31
	AVE. 3.78	AVE. 1.65	AVE. 1.51	AVE. 3.15		AVE. 2.67	AVE. 1.60	AVE. 2.12	AVE. 1.25	AVE. 3.26	AVE. 1.20
	2.98 2.99	1.63 1.27	1.41 1.41	3.24 3.18		2.64 2.75	1.62 1.45	1.74 2.03	1.64 1.43	2.69 2.98	1.41 1.24
	2.94 2.81	1.72 1.71	1.49 1.39	4.34 2.86		2.38 3.14	1.47 1.54	1.83 2.01	1.34 1.23	2.33 3.06	1.34 1.30
	3.76 3.33	1.89 1.90	1.41 1.19	3.75 2.79		2.34 3.06	1.64 1.51	2.15 1.99	1.23 1.31	2.14 2.82	1.38 1.43
	4.61 3.69	1.91 1.42	1.26 1.51	4.58 3.37		2.75 3.11	1.62 1.61	2.13 2.04	1.16 1.22	2.25 2.91	1.11 1.36
	5.31 3.80	1.62 1.53	1.32 1.41	3.38 3.38		3.02 3.30	1.66 1.48	2.37 2.22	1.14 1.33	3.53 3.18	1.27 1.37
	5.22 3.54	1.55 1.50	1.21 1.47	3.79 4.68		2.80 3.02	1.47 1.40	2.62 2.18	1.18 1.35	2.89 3.30	1.21 1.35
	AVE. 3.75	AVE. 1.56	AVE. 1.21	AVE. 3.61		AVE. 2.86	AVE. 1.54	AVE. 2.11	AVE. 1.30	AVE. 3.18	AVE. 1.30
	3.15 3.00	2.01 2.21	1.16 1.12	2.84 2.86		2.28 2.48	1.37 1.35	2.41 2.36	1.36 1.23	2.77 2.55	1.23 1.26
	3.49 2.85	1.94 2.09	1.05 1.09	3.73 3.18		2.25 2.57	1.32 1.23	1.97 2.29	1.27 1.03	2.49 2.37	1.21 1.35
	4.17 3.85	2.03 1.97	1.02 1.04	4.27 3.78		2.46 2.75	1.45 1.39	2.03 2.06	1.46 1.06	2.51 2.08	1.33 1.24
	4.62 4.29	1.86 1.72	1.37 1.20	4.03 4.15		2.69 3.07	1.61 1.46	1.98 1.88	1.32 .99	2.94 1.90	1.20 1.22
	4.40 4.10	1.73 1.95	1.24 1.26	3.88 3.90		3.01 3.21	1.57 1.53	2.13 1.72	1.36 .98	2.54 2.25	1.26 1.14
	4.45 3.93	1.39 1.78	1.36 1.19	3.30 3.92		2.83 2.81	1.56 1.46	2.25 1.63	1.41 1.21	2.68 3.14	1.21 1.34
	AVE. 3.86	AVE. 1.90	AVE. 1.18	AVE. 3.65		AVE. 2.70	AVE. 1.44	AVE. 2.20	AVE. 1.25	AVE. 2.52	AVE. 1.31

CB2A		B3X		CB3X		B4X		ER3X		ET4X		AR3X		AT4X		AR3A		AT4A		SR3A		ST4A	
2.44	2.93	1.40	1.37	1.76	1.81	1.77	1.52	1.56	1.52	1.31	1.41	1.37	1.57	2.01	1.74	4.58	3.95	1.94	2.01	4.91	3.92	3.56	3.62
2.45	3.24	1.36	1.41	1.57	1.73	1.66	1.64	1.54	1.41	1.33	1.39	1.71	1.41	1.75	1.88	2.74	2.65	1.86	1.98	4.62	4.15	3.25	3.17
2.37	2.98	1.68	1.31	1.61	1.83	1.71	1.66	1.49	1.43	1.28	1.37	1.83	1.58	1.95	1.82	2.31	2.12	1.76	1.83	4.09	4.13	3.14	3.45
2.32	2.81	1.46	1.34	1.51	1.69	1.67	1.57	1.34	1.39	1.24	1.28	1.53	1.70	2.22	1.94	2.09	2.07	1.91	1.77	3.59	3.91	2.93	3.39
2.29	2.86	1.35	1.38	1.65	1.65	1.63	1.55	1.48	1.36	1.29	1.26	1.56	1.66	2.41	1.89	2.17	2.11	1.98	1.75	4.00	3.48	2.71	3.66
2.72	3.01	1.41	1.54	1.63	1.80	1.49	1.44	1.46	1.41	1.31	1.30	1.38	1.64	2.18	1.87	2.97	2.76	1.99	1.91	3.29	3.19	2.73	3.39
AVE. 2.87		AVE. 1.43		AVE. 1.68		AVE. 1.61		AVE. 1.49		AVE. 1.32		AVE. 1.58		AVE. 1.97		AVE. 2.71		AVE. 1.89		AVE. 3.94		AVE. 3.24	
2.86	2.61	1.51	1.34	1.79	1.73	1.85	1.61	1.33	1.46	1.69	1.62	1.58	1.50	1.57	1.98	2.97	3.61	2.14	2.46	4.37	3.88	3.34	2.90
2.78	2.63	1.54	1.23	1.53	1.86	1.79	1.69	1.46	1.42	1.55	1.54	1.65	1.48	1.52	1.67	2.20	2.32	2.19	2.34	4.22	3.97	3.20	2.81
2.93	2.57	1.36	1.22	1.68	1.93	1.68	1.54	1.33	1.40	1.46	1.52	1.57	1.46	2.20	1.64	2.16	2.06	2.04	2.03	4.44	3.98	3.17	2.87
2.67	2.29	1.38	1.26	1.62	1.71	1.73	1.68	1.37	1.41	1.34	1.45	1.47	1.47	2.01	1.69	2.13	2.09	1.85	1.92	3.20	4.00	3.00	2.88
2.92	2.24	1.27	1.33	1.59	1.59	1.74	1.71	1.41	1.45	1.48	1.41	1.43	1.57	1.61	1.75	2.31	2.76	1.87	1.90	3.51	3.57	3.02	2.80
3.18	2.71	1.59	1.24	1.73	1.83	1.57	1.50	1.42	1.27	1.50	1.36	1.55	1.78	2.19	1.90	3.25	1.99	1.95	1.87	4.21	3.28	3.57	3.01
AVE. 2.87		AVE. 1.36		AVE. 1.72		AVE. 1.63		AVE. 1.39		AVE. 1.49		AVE. 1.54		AVE. 1.81		AVE. 2.49		AVE. 2.05		AVE. 3.89		AVE. 3.05	
2.89	2.54	1.41	1.50	1.69	1.63	1.47	1.63	1.67	1.41	1.40	1.40	1.95	1.90	1.60	2.04	3.54	3.45	1.66	2.41	4.45	4.01	3.27	2.92
3.13	2.52	1.39	1.45	1.67	1.79	1.67	1.51	1.49	1.49	1.27	1.38	1.67	1.78	1.65	2.09	2.36	2.61	1.72	1.97	4.15	3.87	3.13	2.89
3.04	2.49	1.64	1.21	1.79	1.89	1.51	1.60	1.36	1.46	1.21	1.38	1.69	1.80	1.96	1.65	2.27	2.29	1.81	1.97	4.63	4.13	3.04	2.82
2.91	2.28	1.43	1.16	1.71	1.75	1.58	1.96	1.47	1.34	1.19	1.25	1.74	1.71	1.77	1.69	2.09	2.16	1.62	1.86	4.37	3.80	2.89	2.67
2.94	2.41	1.41	1.28	1.80	1.79	1.75	1.73	1.51	1.43	1.41	1.23	1.81	1.76	2.04	1.76	2.52	2.19	1.73	1.61	3.79	3.33	3.29	3.06
2.93	2.53	1.45	1.61	1.89	1.86	1.58	1.52	1.54	1.31	1.36	1.26	1.79	1.79	2.08	2.01	3.34	2.61	1.85	1.67	3.16	2.87	3.26	2.77
AVE. 2.88		AVE. 1.43		AVE. 1.59		AVE. 1.63		AVE. 1.46		AVE. 1.33		AVE. 1.78		AVE. 1.86		AVE. 2.62		AVE. 1.83		AVE. 3.88		AVE. 3.00	
2.73	2.68	1.81	1.65	1.79	1.50	1.38	1.33	1.41	1.75	1.51	1.56	1.67	1.78	1.77	1.71	5.64	5.65	1.61	1.79	4.18	3.50	3.41	3.11
3.11	2.42	1.54	1.63	1.76	1.86	1.44	1.31	1.39	1.43	1.43	1.49	1.76	1.69	1.54	1.73	4.74	5.75	1.73	1.68	4.23	3.83	3.21	2.94
2.96	2.28	1.51	1.61	1.74	1.92	1.46	1.33	1.37	1.39	1.37	1.31	1.78	1.75	1.55	1.61	4.50	5.24	1.66	1.62	4.38	4.08	3.23	2.93
2.89	2.19	1.77	1.52	1.81	1.61	1.30	1.36	1.40	1.41	1.32	1.36	1.85	1.91	1.63	1.63	4.15	5.29	1.89	1.54	2.73	3.54	3.03	2.81
3.08	2.25	1.82	1.67	1.71	1.81	1.41	1.43	1.53	1.45	1.39	1.37	1.69	1.92	2.00	1.96	5.63	5.63	1.87	1.57	3.53	3.36	3.12	2.89
3.12	2.71	1.61	1.73	1.76	1.83	1.18	1.22	1.45	1.40	1.37	1.37	1.86	1.94	2.07	1.92	5.71	5.61	1.96	1.54	2.98	3.18	3.42	3.47
AVE. 2.87		AVE. 1.65		AVE. 1.59		AVE. 1.35		AVE. 1.43		AVE. 1.40		AVE. 1.80		AVE. 1.76		AVE. 5.29		AVE. 1.70		AVE. 3.63		AVE. 3.13	

APPENDIX XVI.—WEIGHT OF TIN COATING ON RUSTED TIN PLATE, 1917 EXPERIMENT.

Weights of Tin Coating on Rusted Sheets that were Exposed in Dec: 1917

R1X		R1X		R1A		R1A		CR1X		CR1X		CR1A		CR1A		T1X		T1X	
1.31	1.35	1.38	1.56	1.72	2.62			1.72	1.55	1.40	1.41	1.83	2.39	2.41	2.70	1.07	1.21	1.44	1.45
1.32	1.25	1.41	1.42	1.63	1.85			1.62	1.51	1.35	1.33	1.81	2.39	1.72	1.88	1.07	1.21	1.30	1.43
1.34	1.25	1.43	1.42	1.63	1.91			1.53	1.50	1.38	1.36	1.81	2.31	1.74	2.00	1.02	1.16	1.32	1.41
1.26	1.25	1.44	1.46	1.71	1.84			1.42	1.44	1.36	1.35	1.97	2.34	1.74	1.89	1.10	1.24	1.33	1.46
1.38	1.35	1.45	1.58	1.76	1.87			1.53	1.51	1.44	1.36	2.08	2.41	1.86	2.00	1.16	1.26	1.40	1.51
1.45	1.37	1.45	1.67	1.84	1.96			1.61	1.61	1.73	1.38	2.24	2.48	2.07	2.16	1.17	1.26	1.53	1.42
Av.-1.32		Av.-1.49		Av-1.86				Av-1.55		Av-1.40		Av-2.15		Av-2.01		Av.-1.16		Av.-1.42	

T1A		T1A		CT1X		CT1X		CT1A		CT1A		R2X		R2X		R2A		R2A	
1.75	1.66	1.61	1.64	1.37	1.29	1.69	1.53	2.96	2.47	2.75	1.83	1.40	1.32	1.31	1.29	1.80	2.40	3.34	3.13
1.63	1.65	1.72	1.74	1.36	1.26	1.48	1.42	2.58	2.18	2.07	1.76	1.30	1.25	1.33	1.21	1.90	1.98	2.34	2.37
1.73	1.73	1.68	1.75	1.38	1.27	1.46	1.31	2.63	2.38	2.07	1.91	1.38	1.41	1.36	1.22	1.92	1.96	1.95	2.15
1.74	1.81	1.77	1.83	1.38	1.27	1.45	1.35	2.36	2.10	1.99	1.89	1.46	1.41	1.34	1.27	2.09	1.99	1.97	2.14
1.79	1.89	1.90	1.91	1.39	1.36	1.51	1.33	2.50	2.31	2.19	2.17	1.44	1.42	1.41	1.37	2.21	2.01	1.97	2.20
1.94	2.03	2.12	2.08	1.44	1.52	1.67	1.45	2.32	2.27	2.24	2.28	1.94	1.31	1.48	1.52	2.47	2.11	1.91	2.29
Av-1.78		Av-1.81		Av-1.36		Av-1.47		Av-2.42		Av-2.10		Av-1.46		Av-1.34		Av-2.07		Av.-2.31	

CR2X		CR2X		CR2A		CR2A		T2X		T2X		T2A		T2A		CT2X		CT2X	
1.49	1.43	1.59	1.61		2.71	2.92	2.07	1.44	1.22	1.22	1.26	2.76	2.61	2.03	2.01	1.57	1.63	1.41	1.50
1.44	1.39	1.47	1.50	2.31	1.78	1.90	1.75	1.35	1.11	1.33	1.29	2.86	2.37	1.98	1.84	1.42	1.47	1.39	1.40
1.43	1.42	1.52	1.48	1.85	1.71	1.88	1.69	1.34	1.09	1.32	1.24	2.65	2.38	1.95	1.73	1.40	1.42	1.36	1.42
1.57	1.46	1.54	1.61	1.72	1.65	1.90	1.83	1.32	1.12	1.39	1.39	2.43	2.08	1.93	1.66	1.41	1.44	1.40	1.46
1.61	1.52	1.61	1.66	1.86	1.76	2.01	1.98	1.28	1.11	1.48	1.37	2.48	2.08	1.91	1.66	1.55	1.55	1.47	1.55
1.79	1.74	1.87	1.78	1.96	2.05	2.35	2.36	1.28	1.07	1.54	1.35	2.57	2.17	2.77	1.67	1.60	1.55	1.63	1.78
Av.-1.53		Av-1.60		Av-1.94		Av.-2.07		Av-1.23		Av.-1.35		Av-2.45		Av-1.93		Av.-1.50		Av.-1.48	

CT2A		CT2A		R3X		R3X		R3A		R3A		CR3X		CR3X		CR3A		CR3A	
3.04	2.37	2.96	2.42	1.31	1.28	1.35	1.36	1.60	1.79	1.76	1.88	1.71	1.75	1.45	1.56	1.57	1.83	1.60	1.75
1.92	1.86	2.12	1.95	1.35	1.31	1.31	1.31	1.66	1.80	1.67	1.87	1.37	1.38	1.41	1.41	1.54	1.66	1.65	1.73
2.01	1.82	2.22	1.99	1.36	1.29	1.33	1.25	1.71	1.89	1.78	1.98	1.42	1.37	1.48	1.38	1.55	1.66	1.60	1.75
1.91	1.91	2.17	2.08	1.41	1.28	1.32	1.28	1.82	2.00	1.80	2.01	1.42	1.39	1.43	1.42	1.66	1.67	1.63	1.83
1.99	2.02	2.40	2.22	1.40	1.30	1.42	1.31	2.00	2.16	2.01	2.06	1.49	1.43	1.51	1.42	1.80	1.79	1.77	1.94
2.13	2.15	2.64	2.37	1.45	1.33	1.49	1.29	2.26	2.17	2.15	2.19	1.52	1.50	1.61	1.60	2.05	1.93	1.95	2.13
Av-2.12		Av-2.30		Av.-1.34		Av-1.34		Av-1.90		Av-1.93		Av-1.48		Av-1.47		Av.-1.73		Av.-1.77	

Weights of Tin Coating on Rusted Sheets that were Exposed in Dec., 1917

T3X		T3X		T3A		T3A		CT3X		CT3X		CT3A		CT3A		R4X		R4X	
1.44	1.27	1.29	1.38	2.26	2.81	2.37	2.70	1.54	1.62	1.33	1.31	3.51	3.06	1.74	2.62	1.54	1.49	1.44	1.42
1.33	1.34	1.24	1.41	1.58	1.80	1.60	1.82	1.38	1.48	1.26	1.30	2.67	2.21	1.72	1.99	1.37	1.42	1.43	1.42
1.29	1.14	1.22	1.32	1.64	1.85	1.58	1.88	1.38	1.46	1.30	1.25	2.66	2.08	1.89	2.14	1.32	1.40	1.39	1.32
1.29	1.18	1.25	1.32	1.75	1.96	1.64	1.88	1.38	1.37	1.30	1.17	2.30	2.00	1.82	2.07	1.39	1.49	1.39	1.36
1.32	1.21	1.32	1.44	1.96	1.97	1.79	2.02	1.49	1.46	1.33	1.26	2.47	2.16	1.98	2.22	1.34	1.42	1.46	1.43
1.38	1.38	1.86	1.56	2.36	2.04	2.11	2.25	1.56	1.51	1.52	1.30	2.84	2.53	2.11	2.39	1.45	1.49	1.52	1.45
Av.-1.29		Av-1.38		Av-1.99		Av-1.97		Av-1.47		Av-1.30		Av-2.54		Av.-2.05		Av-1.42		Av-1.42	

R4A		R4A		T4X		T4X		T4A		T4A		R5X		R5X		R5A		R5A	
2.72	1.81	2.85	2.11	1.28	1.41	1.23	1.34	3.62	3.07	1.37	1.75	1.26	1.32	1.68	1.65	1.60	1.68	2.73	3.12
1.74	1.97	1.71	1.61	1.22	1.36	1.19	1.34	2.65	2.10	1.39	1.63	1.21	1.19	1.53	1.45	1.54	1.76	2.78	2.40
1.70	1.66	1.77	1.59	1.23	1.32	1.21	1.32	2.26	2.02	1.49	1.65	1.28	1.20	1.55	1.46	1.60	1.79	2.57	2.03
1.78	1.78	1.80	1.60	1.27	1.35	1.25	1.32	2.19	1.96	1.64	1.72	1.32	1.22	1.56	1.50	1.71	1.89	2.25	2.06
1.87	1.80	1.92	1.79	1.34	1.36	1.27	1.33	2.38	2.16	1.79	1.74	1.37	1.30	1.65	1.60	1.89	2.06	2.16	2.01
1.90	1.97	2.02	1.97	1.45	1.42	1.33	1.37	2.61	2.21	2.10	1.83	1.49	1.42	1.79	1.87	2.09	2.30	2.28	2.16
Av-1.89		Av 1.89		Av-1.33		Av-1.29		Av-2.43		Av-1.67		Av-1.29		Av-1.61		Av-1.82		Av.-2.38	

T5X		T5X		T5A		T5A		R6X		R6X		R6A		R6A		T6X		T6X	
1.27	1.40	1.41	1.24	2.17	1.86	2.39	1.99	1.30	1.26	1.30	1.34	2.16	1.69	3.04	3.06	1.58	1.63	1.41	1.33
1.28	1.27	1.23	1.16	1.64	1.80	1.77	1.84	1.34	1.19	1.28	1.29	1.66	1.72	1.99	2.13	1.48	1.45	1.29	1.16
1.30	1.26	1.26	1.18	1.71	1.82	1.85	1.92	1.32	1.18	1.28	1.25	1.72	1.75	1.85	2.13	1.51	1.43	1.33	1.19
1.34	1.31	1.28	1.19	1.83	1.76	1.97	1.87	1.34	1.21	1.33	1.32	1.81	1.75	1.85	2.10	1.58	1.43	1.33	1.24
1.38	1.36	1.29	1.26	1.97	1.87	2.08	1.98	1.31	1.26	1.40	1.37	1.96	1.87	2.01	2.13	1.58	1.48	1.42	1.35
1.41	1.45	1.40	1.46	2.02	1.86	2.18	2.06	1.33	1.35	1.48	1.47	2.10	1.99	2.11	2.10	1.71	1.46	1.45	1.42
Av.-1.33		Av-1.28		Av-1.86		Av-1.99		Av-1.27		Av-1.34		Av-1.85		Av-2.21		Av-1.54		Av.-1.33	

T6A		T6A		R7X		R7X		R7A		R7A		T7X		T7X		T7A		T7A	
2.97	2.11	2.88	1.97	1.33	1.24	1.23	1.38	1.71	2.68	2.95	2.70	1.33	1.43	1.25	1.39	2.43	1.72	3.01	3.21
1.93	1.82	1.91	1.75	1.13	1.23	1.17	1.32	1.44	1.84	2.64	2.10	1.32	1.36	1.18	1.42	1.75	1.68	2.17	2.50
1.89	1.81	1.79	1.68	1.09	1.17	1.19	1.28	1.57	1.81	2.31	1.87	1.26	1.32	1.22	1.35	1.74	1.66	1.92	2.17
1.98	1.88	2.00	1.81	1.09	1.17	1.23	1.29	1.58	1.92	2.20	1.83	1.27	1.36	1.21	1.34	1.83	1.75	2.04	2.21
2.26	1.97	2.26	1.99	1.15	1.16	1.23	1.32	1.75	1.93	2.18	1.77	1.32	1.39	1.23	1.37	1.93	1.81	2.18	2.43
2.59	2.01	2.54	2.11	1.18	1.26	1.41	1.42	1.87	2.00	2.29	1.93	1.37	1.58	1.31	1.33	2.00	1.85	2.07	2.55
Av.-2.04		Av.-2.07		Av.-1.18		Av.-1.29		Av.-1.84		Av.-2.28		Av.-1.35		Av.-1.30		Av.-1.85		Av.-2.37	

Weights of Tin Coating on Rusted Sheets that were Exposed in Dec 1917

H1X		H1X		H1A		H1A		CH1X		CH1X		CH1A		CH1A		H2X		H2X	
1.30	1.18	1.19	1.18	1.64	1.62	2.33	1.79	1.71	1.69	1.67	1.58	2.07	2.61	2.76	2.44	1.35	1.43	1.26	1.20
1.32	1.27	1.27	1.14	1.80	1.82	2.02	2.09	1.68	1.64	1.48	1.56	2.10	2.53	2.75	2.34	1.34	1.36	1.20	1.16
1.24	1.22	1.13	1.09	1.81	1.81	1.94	2.00	1.70	1.62	1.46	1.52	2.21	2.38	2.69	2.22	1.33	1.38	1.10	1.22
1.31	1.28	1.14	1.09	1.97	1.98	1.63	1.89	1.68	1.58	1.46	1.50	1.94	2.27	2.65	2.54	1.37	1.48	1.06	1.36
1.28	1.19	1.06	1.17	2.15	2.09	1.73	1.94	1.68	1.78	1.32	1.32	2.26	2.28	2.65	2.29	1.23	1.21	1.02	1.10
1.34	1.14	1.14	1.15	2.30	2.28	2.40	1.86	1.64	1.67	1.40	1.24	2.17	2.20	2.45	2.58	1.25	1.16	1.02	1.18
Av.-1.26		Av.-1.15		Av.-1.94		Av.-1.97		Av.-1.67		Av.-1.46		Av.-2.25		Av.-2.53		Av.-1.34		Av.-1.16	

H2A		H2A		CH2X		CH2X		CH2A		CH2A		H3X		H3X		H3A		H3A	
2.40	3.66	3.31	2.17	1.25	1.35		1.25	2.23	2.43	2.48	1.96	1.31	1.48	1.47	1.56	5.00	4.01	2.82	3.21
2.34	3.66	3.47	2.25	1.23	1.29	1.25	1.27	2.27	2.57	2.14	2.03	1.26	1.28	1.45	1.65	3.78	4.43	3.45	3.70
2.30	3.85	3.70	2.36	1.31	1.34	1.19	1.33	2.22	2.37	2.28	2.05	1.26	1.32	1.42	1.58	4.11	4.57	4.54	4.76
2.44	3.76	3.54	2.52	1.23	1.29	1.22	1.27	2.30	2.38	2.17	2.18	1.41	1.36	1.47	1.57	3.89	4.24	4.62	5.05
2.61	3.71	3.28	2.71	1.22	1.27	1.21	1.27	2.03	2.11	2.23	2.28	1.30	1.15	1.47	1.47	3.16	3.17	4.23	4.12
2.95	3.18	3.22	3.02	1.30	1.20	1.19	1.18	2.02	1.78	2.36	2.37	1.25	1.08	1.30	1.47	2.86	3.04	3.65	3.48
Av.-3.07		Av.-2.96		Av.-1.27		Av.-1.24		Av.-2.23		Av.-2.21		Av.-1.29		Av.-1.49		Av.-3.86		Av.-3.97	

CH3X		CH3X		CH4Z		CH4Z		B1X		B1X		B1A		B1A		CB1X		CB1X	
0.97	1.09	1.33	1.16	2.59	2.60	2.48	2.84	1.25	1.24	1.31	1.18	2.67	2.18	2.10	2.11	1.26	1.28	1.55	1.43
0.98	1.03	1.37	1.13	2.78	2.88	2.87	3.38	1.25	1.17	1.23	1.25	2.69	2.44	2.23	1.98	1.27	1.31	1.42	1.39
1.06	1.04	1.30	1.18	2.83	2.98	2.92	4.02	1.32	1.14	1.27	1.23	2.96	2.59	2.51	2.09	1.17	1.20	1.36	1.44
0.95	1.05	1.37	1.13	3.05	3.02	3.05	4.21	1.26	1.19	1.28	1.18	3.09	2.64	2.78	2.53	1.23	1.26	1.37	1.40
0.98	1.05	1.35	1.16	2.48	2.85	2.82	3.87	1.26	1.18	1.29	1.18	2.90	2.67	3.09	2.59	1.19	1.20	1.37	1.24
0.95	0.97	1.33	1.15	2.53	2.96	2.94	3.48	1.11	1.18	1.21	1.17	2.22	2.63	2.88	2.52	1.14	1.18	1.20	1.31
Av.-1.10		Av.-1.25		Av.-2.79		Av.-3.24		Av.-1.23		Av.-1.23		Av-2.64		Av.-2.45		Av.-1.22		Av.-1.37	

CB1A		CB1A		B2X		B2X		B2A		B2A		CB2X		CB2X		CB2A		CB2A	
2.26	2.00	2.24	2.17	1.35	1.22	1.41	1.38	3.17	3.18	2.69	3.21	1.11	1.15	1.27	1.43	2.84	2.72	3.06	2.58
2.14	1.87	2.21	1.96	1.20	1.21	1.30	1.41	3.11	2.61	2.58	3.24	1.13	1.29	1.19	1.33	2.58	2.42	2.87	2.28
1.94	1.55	2.20	1.76	1.15	1.19	1.36	1.25	2.81	2.29	2.69	2.68	1.15	1.39	1.15	0.97	2.54	2.02	2.68	2.12
1.77	1.45	2.24	1.76	1.22	1.13	1.31	1.22	2.54	2.15	2.60	2.31	1.19	1.25	1.71	0.97	2.60	2.14	2.61	2.26
1.82	1.74	2.15	1.86	1.19	1.14	1.25	1.15	2.49	2.21	2.40	2.16	1.03	1.37	1.10	0.97	2.73	2.34	2.78	2.51
2.07	1.96	2.33	2.13	1.33	1.05	1.23	1.17	2.51	2.71	2.81	2.39	1.05	1.25	0.99	0.99	2.74	2.25	2.76	2.34
Av.-1.38		Av.-2.09		Av.-1.19		Av.-1.29		Av.-2.65		Av.-2.64		Av.-1.19		Av.-1.17		Av.-2.49		Av.-2.57	

The following includes determinations on some sheets of commercial plate secured from Baltimore can factories and exposed March, 1918, for comparison with sheets of experimental plate exposed at the same time. The designations SI, SK, SM, SN, SO, SP, SR, SS, ST, SV, SW, SX, SY, and SZ, have no relation to the composition or coating of the plate.

Weights of Tin Coating on Rusted Sheets that were Exposed in Dec 1917 or Later as Noted

B3X		B3X		CB3X		CB3X		B4X		B4X		ER3X		ER3X		ET4X		ET4X	
1.04	1.13	1.63	1.41	1.61	1.55	1.50	1.33	1.59	1.52	1.57	1.71	1.43	1.33	1.17	1.41	1.21	1.35	1.28	1.41
1.27	1.21	1.27	1.38	1.51	1.59	1.53	1.41	1.60	1.59	1.68	1.72	1.36	1.29	1.23	1.35	1.23	1.33	1.32	1.32
1.15	1.10	1.18	1.19	1.69	1.67	1.46	1.45	1.46	1.60	1.54	1.65	1.32	1.26	1.18	1.29	1.23	1.33	1.34	1.32
1.14	1.10	1.13	1.15	1.75	1.57	1.37	1.46	1.56	1.57	1.56	1.60	1.19	1.23	1.17	1.29	1.28	1.40	1.33	1.30
1.15	1.16		1.09	1.63	1.49	1.32	1.48	1.53	1.61	1.59		1.16	1.26	1.24	1.33	1.32	1.38	1.41	1.40
1.33	1.22	1.12	1.09	1.43	1.45	1.30	1.42	1.41	1.55	1.62	1.66	1.30	1.37	1.23	1.27	1.43	1.47	1.45	1.47
Av - 1.17		Av - 1.24		Av - 1.58		Av - 1.34		Av - 1.54		Av - 1.72		Av - 1.29		Av - 1.26		Av - 1.33		Av. - 1.36	

AR3X		AR3X		AT4X		AT4X		AR3A		AR3A		AT4A		AT4A		SR3A		SR3A	
2.08	1.62	1.72	1.63	2.10	1.61	1.68	1.77	1.78	1.48	1.78	2.10	1.65	1.83	1.39	1.62	4.51	4.31	3.06	3.08
2.13	1.56	1.55	1.48	2.03	1.56	1.64	1.60	1.65	1.52	1.77	1.87	1.67	1.80	1.38	1.51	4.45	4.34	2.91	3.24
1.83	1.53	1.56	1.45	1.82	1.71	1.57	1.65	1.74	1.55	1.82	1.83	1.78	1.83	1.53	1.56	4.41	4.22	3.39	3.80
1.83	1.59	1.50	1.43	1.68	1.57	1.44	1.69	1.90	1.58	1.88	1.98	1.67	1.83	1.73	1.53	4.12	3.84	3.84	4.19
1.87	1.53	1.45	1.45	1.74	1.65	1.46	1.48	2.11	1.72	2.05	2.13	1.92	1.93	1.61	1.80	3.15	3.25	3.96	4.07
1.62	1.65	1.37	1.43	1.84	1.62	1.59	1.74	2.15	1.77	2.22	2.20	2.04	1.92	1.74	1.81	2.86	3.04	3.92	3.89
Av - 1.74		Av - 1.50		Av - 1.74		Av. - 1.61		Av - 1.75		Av - 1.97		Av - 1.81		Av - 1.60		Av - 3.87		Av - 3.61	

Exposed in March, 1918 :-

ST4A		ST4A		T7A		R4A		SI		SK		SM		SN		SO		SP	
3.52	3.58		3.76	1.54	1.61	2.68	2.04	1.25	1.15	1.42	1.30	1.25	1.25	1.31	0.85	1.75	1.63	1.32	1.24
3.31	3.37	3.57	3.51	1.50	1.53	1.89	1.62	1.25	1.15	1.36	1.24	1.23	1.21	1.27	0.93	1.51	1.61	1.28	1.22
3.16	3.12	3.46	3.30	1.58	1.52	1.85	1.65	1.24	1.19	1.32	1.24	1.15	1.15	1.09	0.95	1.59	1.61	1.26	1.22
3.02	2.91	3.14	2.98	1.65	1.60	1.93	1.71	1.27	1.17	1.30	1.20	1.15	0.98	1.01	0.89	1.55	1.53	1.34	1.16
2.81	2.80	2.89	2.86	1.82	1.72	2.02	1.88	1.33	1.29	1.10	1.16	1.15	1.07	0.95	0.87	1.57	1.57	1.22	1.20
3.08	3.29	3.08	3.41	2.03	1.87	2.15	2.20	0.97	1.29	1.30	1.20	1.13	1.09	1.05		1.59	1.63	1.20	
Av - 3.16		Av - 3.27		Av - 1.66		Av - 1.97		Av - 1.20		Av - 1.21		Av - 1.15		Av - 1.01		Av - 1.59		Av - 1.24	

Exposed in March, 1918.-

SR		SS		ST		SV		SW		SX		SY		SZ		T3X		R4X	
1.31	1.37	1.82	1.42	1.34	1.16	1.70	1.68	1.23	1.31	1.05	1.23	1.24	1.26	1.53	1.61	1.47	1.39	1.65	1.73
1.33	1.25	1.33	1.49	1.24	1.14	1.80	1.70	1.07	1.38	1.11	1.33	1.34	1.28	1.79	1.35	1.42	1.34	1.77	1.48
1.29	1.21	1.31	1.48	1.22	1.08	1.62	1.44	1.12	1.36	0.93	1.13	1.34	1.36	1.41	1.31	1.41	1.33	1.53	1.53
1.29	1.23	1.33	1.39	1.18	1.02	1.62	1.60	1.10	1.34	0.85	1.17	1.28	1.14	1.47	1.27	1.51	1.38	1.61	1.54
1.33	1.21	1.56	1.41	1.22	1.00	1.58	1.46	0.99	1.09	1.07	1.25	1.10	1.08	1.23	1.33	1.53	1.40	1.68	1.61
1.35	1.23	1.28	1.35	1.28	1.12	1.40	1.10	0.98	1.10	1.09	1.15	0.98	1.08	1.11	1.07	1.66	1.46	1.87	1.67
Av - 1.28		Av - 1.43		Av - 1.17		Av - 1.56		Av - 1.17		Av. - 1.11		Av - 1.21		Av - 1.37		Av - 1.44		Av. - 1.64	

Weights of Tin Coating on Rusted Sheets that were Exposed in March, 1918

T4X		T4A		R5X		R5A		T5A		R6A		R7X		R7A		T7X		H1X	
1.56	1.55	2.24	1.68	1.37	1.44	1.70	2.61	3.48	3.66	1.70	3.13	1.52	1.48	2.82	1.82	1.25	1.32	1.00	1.02
1.22	1.28	1.72	1.75	1.31	1.36	1.62	1.81	2.50	2.48	1.89	2.21	1.41	1.36	1.58	1.64	1.15	1.23	1.04	1.01
1.16	1.22	1.72	1.75	1.33	1.34	1.57	1.80	2.30	1.99	1.87	2.12	1.30	1.28	1.63	1.56	1.22	1.32	1.36	1.02
1.15	1.17	1.82	1.82	1.37	1.39	1.71	1.84	2.12	2.02	1.81	2.05	1.33	1.34	1.62	1.54	1.26	1.32	1.30	1.02
1.15	1.29	1.99	1.97	1.37	1.43	1.82	1.98	2.22	2.08	1.81	2.09	1.38	1.37	1.69	1.71	1.24	1.30	1.16	0.98
1.19	1.38	2.06	2.01	1.51	1.76	1.99	2.03	2.29	2.17	1.94	2.11	1.55	1.51	1.76	1.74	1.30	1.48	1.00	0.98
Av.- 1.28		Av.- 1.88		Av.- 1.41		Av.- 1.66		Av.- 2.44		Av.- 2.06		Av.- 1.40		Av.- 1.76		Av.- 1.28		Av.- 1.08	

H1A		CH1X		CH1A		H2X		H2A		H2A		CH2X		CH2A		H3X		H3A	
2.55	2.79	1.47	1.43	2.33	2.62	1.13	1.24	2.99	2.13	4.19	2.53	1.35	1.36	2.56	2.98	1.13	1.01	3.54	3.82
2.38	2.46	1.51	1.44	2.01	2.67	1.17	1.13	2.93	2.14	4.40	2.71	1.30	1.26	3.24	3.14	1.13	1.03	3.94	4.36
2.12	2.29	1.40	1.28	2.42	2.70	1.13	1.12	3.32	2.15	4.55	2.86	1.36	1.26	3.02	2.56	1.11	1.03	4.37	4.57
2.02	2.31	1.36	1.35	2.01	2.61	1.12	1.25	2.98	2.16	4.46	3.07	1.34	1.18	2.76	2.84	1.05	1.03	4.62	4.66
2.02	2.32	1.35	1.40	2.12	2.48	1.11	1.04	2.78	2.20	4.16	3.43	1.24	1.13	2.28	2.70	1.11	1.03	3.63	3.94
2.00	2.01	1.37	1.40	2.23	2.43	1.07	1.01	2.82	2.37	4.36	4.17	1.24	1.05	2.18	2.40	1.11	1.01	2.85	3.05
Av.- 2.26		Av.- 1.39		Av.- 2.39		Av.- 1.13		Av.- 2.58		Av.- 3.77		Av.- 1.27		Av - 2.72		Av.- 1.07		Av.- 3.94	

CH3X		CH4Z		B1X		B1A		CB1X		CB1A		B2X		B2A		CB2X		CB2A	
1.30	1.16	4.42	4.19	1.19	1.20	3.08	2.69	1.35	1.39	2.18	2.00	1.39	1.85	3.29	3.67	1.13	1.13	2.85	2.70
1.24	1.06	4.16	4.37	1.16	1.21	3.11	2.60	1.41	1.21	1.82	1.67	1.35	1.85	3.51	3.14	1.05	1.07	2.51	2.11
1.26	1.06	4.23	4.66	1.19	1.19	2.92	2.37	1.37	1.13	1.76	1.59	1.31	1.75	3.35	2.85	1.03	1.01	2.52	2.30
1.26	1.20	3.85	4.52	1.19	1.20	2.53	2.14	1.29	1.21	1.97	1.71	1.27	1.73	2.74	2.78	1.09	1.07	2.65	2.28
1.36	1.16	3.47	4.06	1.14	1.28	2.36	2.01	1.33	1.13	2.03	1.77	1.11	1.73	2.75	2.38	1.15	1.13	2.89	2.37
1.42	1.28	2.72	3.31	1.16	1.17	2.14	2.20	1.49	1.09	2.33	2.00	1.09	1.47	2.67	2.48	1.13	1.17	2.64	2.37
Av.- 1.23		Av.- 4.00		Av.- 1.19		Av.- 2.50		Av.- 1.28		Av.- 1.90		Av.- 1.49		Av.- 2.97		Av.- 1.09		Av.- 2.59	

B3X		B4X		ER3X		ET4X		AR3X		AT4X		AR3A		AT4A		SR3A		ST4A	
1.36	1.28	1.68	1.80	1.32	1.40	1.27	1.38	1.74	1.68	1.71	1.75	1.81	1.98	1.49	1.55	3.12	3.09	4.18	3.91
1.38	1.46	1.70	1.70	1.28	1.38	1.29	1.48	1.74	1.63	1.74	1.64	1.60	1.97	1.38	1.58	3.65	3.56	3.44	3.51
1.50	1.46	1.56	1.54	1.20	1.26	1.31	1.33	1.63	1.58	1.82	1.83	1.62	2.01	1.34	1.56	4.41	4.16	3.22	3.29
1.40	1.34	1.44	1.52	1.14	1.25	1.39	1.37	1.69	1.62	1.79	1.80	1.88	2.11	1.43	1.54	4.58	4.13	2.97	3.00
1.36	1.32	1.60	1.54	1.12		1.36	1.32	1.63	1.52	1.85	1.82	1.92	2.14	1.53	1.56	3.99	3.96	2.85	2.93
1.48	1.28	1.62	1.52	1.17	1.28	1.55	1.31	1.49	1.52	1.82	1.76	2.10	2.15	1.75	1.57	4.28	3.93	3.26	3.56
Av.- 1.39		Av.- 1.60		Av.- 1.25		Av.- 1.36		Av.- 1.62		Av.- 1.78		Av.- 1.94		Av.- 1.52		Av.- 3.91		Av.- 3.34	

APPENDIX XVII.—ANALYSIS OF STEEL FROM PERFORATED CANS OF 1917 PACK.

TABLE 83.—CARBON, MANGANESE, PHOSPHORUS AND SULPHUR CONTENT OF STEEL FROM PERFORATED CANS OF 1917 EXPERIMENTAL PACK.

BLUEBERRIES.

Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.	Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
R1XN....	0.12	0.37	0.073	0.046	R7ANN...	0.13	0.34	0.113	0.053
R1XN....	.11	.40	.087	.061	R7ANN...	.13	.35	.095	.069
R1XN....	.12	.37	.114	.083					
R1XN....	.12	.31	.107	.055	CR1XN...	.13	.30	.122	.072
R1XNN...	.10	.30	.080	.048	CR1XN...	.11	.28	.066	.029
R1AN....	.10	.37	.092	.061	CR1XN...	.12	.30	.116	.060
R1ANN...	.12	.31	.102	.049	CR1XN...	.11	.32	.057	.035
					CR1XN...	.11	.32	.058	.039
R2XP.....	.13	.31	.146	.064	CR1XN...	.12	.36	.091	.068
R2XN....	.15	.39	.129	.071	CR1XN...	.11	.36	.097	.052
R2XN....	.13	.38	.122	.072	CR1XN...	.11	.36	.085	.063
R2XN....	.13	.38	.126	.073	CR1XNN.	.12	.29	.088	.042
R2XN....	.13	.31	.142	.068	CR1XNN.	.13	.32	.098	.053
R2XN....	.12	.37	.117	.081	CR1XNN.	.10	.38	.084	.061
R2XN....	.15	.37	.122	.081	CR1XNN.	.11	.34	.083	.058
R2XN....	.14	.35	.128	.082	CR1AN...	.11	.37	.091	.068
R2XN....	.15	.31	.140	.067	CR1AN...	.11	.38	.093	.072
R2XNN...	.14	.31	.121	.073	CR1AN...	.11	.39	.104	.079
R2AN....	.13	.31	.144	.079	CR1AN...	.12	.32	.081	.040
R2AN....	.13	.33	.131	.070	CR1AN...	.11	.39	.093	.076
R2AN....	.13	.34	.117	.070	CR1AN...	.10	.39	.084	.071
R2AN....	.13	.39	.127	.076	CR1ANN.	.11	.31	.103	.074
R2AN....	.13	.37	.124	.080	CR1ANN.	.10	.33	.108	.053
R2AN....	.14	.35	.123	.071					
R2ANN...	.12	.32	.188	.067	CR2XN...	.13	.36	.125	.084
R2ANN...	.14	.34	.123	.065	CR2XN...	.13	.35	.113	.092
R2ANN...	.14	.33	.132	.076	CR2XN...	.11	.31	.138	.061
					CR2XN...	.15	.40	.129	.072
R3XN....	.13	.36	.091	.051	CR2XN...	.14	.35	.129	.075
R3XN....	.15	.43	.075	.055	CR2XN...	.13	.38	.110	.073
R3XNN...	.13	.37	.084	.048	CR2XNN.	.10	.34	.098	.061
R3AN....	.14	.39	.096	.058	CR2AN...	.13	.33	.145	.071
R3AN....	.12	.39	.124	.068	CR2AN...	.13	.33	.137	.067
R3AN....	.11	.35	.100	.049	CR2AN...	.13	.31	.140	.071
R3ANN...	.09	.35	.098	.065	CR2AN...	.12	.31	.110	.070
R3ANN...	.12	.42	.113	.055	CR2AN...	.14	.32	.149	.062
					CR2AN...	.13	.37	.122	.077
R4XN....	.11	.34	.073	.055	CR2AN...	.13	.39	.118	.085
R4XN....	.11	.33	.093	.036	CR2AN...	.13	.40	.114	.074
R4XNN...	.13	.33	.066	.060	CR2AN...	.13	.33	.120	.069
R4XNN...	.13	.36	.088	.059	CR2AN...	.13	.39	.126	.076
R4XNN...	.11	.32	.089	.041	CR2AN...	.13	.36	.110	.070
R4XNN...	.12	.32	.091	.052	CR2ANN.	.13	.31	.138	.065
R4XNN...	.12	.37	.113	.074	CR2ANN.	.13	.35	.122	.088
R4XNN...	.13	.35	.094	.052					
R4AN....	.13	.37	.121	.061	CR3XN...	.14	.42	.112	.079
R4AN....	.12	.33	.081	.047	CR3XN...	.15	.39	.112	.081
R4AN....	.13	.36	.105	.062	CR3XN...	.12	.37	.101	.053
R4AN....	.14	.34	.106	.066	CR3XN...	.12	.39	.118	.059
R4ANN...	.11	.33	.063	.050	CR3XN...	.11	.39	.124	.067
R4ANN...	.12	.36	.082	.049	CR3XNN.	.13	.43	.094	.070
R4ANN...	.13	.34	.119	.068	CR3XNN.	.14	.35	.119	.077
R4ANN...	.14	.38	.098	.060	CR3XNN.	.13	.35	.124	.066
					CR3XNN.	.12	.35	.082	.043
R6XN....	.12	.36	.072	.044	CR3AN...	.12	.41	.099	.051
R6XN....	.11	.36	.097	.056	CR3ANN.	.12	.40	.083	.057
R6XN....	.11	.39	.096	.087	CR3ANN.	.13	.34	.086	.050
R6XNN...	.13	.40	.100	.063	CR3ANN.	.12	.32	.091	.053
R6AN....	.13	.40	.094	.065					
R6AN....	.12	.38	.052	.042	T1XN....	.10	.37	.068	.052
R6AN....	.13	.32	.080	.070	T1XN....	.11	.32	.070	.043
R6ANN...	.13	.39	.100	.077	T1XNN...	.13	.41	.065	.061
R6ANN...	.10	.38	.083	.048	T1XNN...	.13	.34	.063	.058
R6ANN...	.13	.43	.089	.060					
R6ANN...	.11	.44	.119	.055	T2XN....	.11	.30	.078	.057
					T2XN....	.09	.32	.126	.064
R7XN....	.11	.34	.082	.050	T2XNN...	.13	.32	.071	.064
R7XNN...	.13	.32	.082	.059	T2XNN...	.10	.28	.080	.065
R7XNN...	.14	.34	.083	.046	T2XNN...	.13	.27	.085	.070
R7AN....	.14	.31	.104	.071	T2ANN...	.16	.39	.084	.070

TABLE 83.—CARBON, MANGANESE, PHORPHORUS AND SULPHUR CONTENT OF STEEL FROM PERFORATED CANS OF 1917 EXPERIMENTAL PACK.—*Continued.*

BLUEBERRIES.—*Continued.*

Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.	Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
T2ANN...	0.12	0.30	0.077	0.064	CT3XNN.	0.10	0.33	0.080	0.059
T3XN....	.10	.29	.074	.036	CT3AN...	.12	.33	.093	.058
T3XN....	.12	.31	.081	.051	CT3ANN..	.10	.27	.079	.051
T3XNN...	.11	.28	.081	.049	CT3ANN..	.10	.33	.080	.051
T3XNN...	.11	.27	.084	.059	CT3ANN..	.10	.27	.065	.034
T3XNN...	.12	.31	.079	.053					
T3AN....	.11	.32	.071	.045	B1XN....	.12	.44	.072	.067
T3ANN...	.09	.30	.077	.046	B1XN....	.13	.39	.088	.059
T3ANN...	.11	.38	.108	.053	B1XN....	.13	.38	.107	.068
					B1XN....	.12	.40	.124	.079
T4XN....	.13	.31	.092	.053	B1AN.....	.11	.39	.100	.059
T4XNN...	.13	.35	.081	.048	B1AN....	.11	.35	.095	.059
T4XNN...	.12	.30	.079	.035	B1ANN...	.11	.37	.116	.066
T4AN....	.14	.36	.106	.055					
T4AN....	.13	.31	.078	.042	B2XNN...	.11	.35	.117	.084
T4AN....	.12	.36	.116	.054	B2XNN...	.12	.38	.117	.080
T4ANN...	.13	.35	.096	.061	B2XNN...	.12	.35	.079	.056
T4ANN...	.12	.28	.104	.046	B2XNN...	.11	.39	.101	.085
T4ANN...	.13	.32	.094	.053					
					B3XN....	.13	.38	.111	.066
T5XN....	.13	.34	.105	.043	B3XNN...	.13	.40	.116	.070
T5XNN...	.12	.34	.082	.041	B3XNN...	.11	.47	.114	.070
T5XNN...	.13	.36	.091	.041	B3XNN...	.12	.37	.125	.094
T5AN....	.13	.36	.110	.078					
T5AN....	.12	.34	.078	.064	B4XN....	.11	.39	.109	.068
T5AN....	.14	.31	.098	.052	B4XNN...	.11	.39	.135	.050
T5AN....	.13	.48	.148	.084	B4XNN...	.12	.39	.123	.080
T5ANN...	.14	.36	.092	.067	B4XNN...	.12	.36	.115	.069
					B4XNN...	.13	.35	.102	.073
T6XN....	.10	.32	.066	.054					
T6XN....	.09	.32	.080	.049	CB1XN...	.13	.34	.100	.049
T6XN....	.11	.32	.069	.038	CB1XN...	.12	.36	.102	.055
T6XN....	.12	.32	.094	.053	CB1XN...	.12	.36	.093	.049
T6XNN...	.13	.33	.085	.049	CB1XNN.	.12	.43	.143	.060
T6XNN...	.13	.32	.080	.054	CB1XNN.	.11	.35	.103	.090
T6XNN...	.13	.32	.094	.059	CB1XNN.	.11	.37	.108	.068
T6AN....	.10	.36	.086	.056	CB1XNN.	.11	.46	.127	.064
T6ANN...	.12	.33	.100	.058	CB1AP...	.12	.36	.112	.070
T6ANN...	.11	.32	.108	.056	CB1AN...	.11	.38	.106	.068
T6ANN...	.11	.34	.061	.044	CB1AN...	.12	.35	.098	.070
T6ANN...	.13	.31	.110	.065	CB1AN...	.12	.36	.097	.068
T6ANN...	.13	.33	.105	.060	CB1AN...	.12	.38	.097	.070
					CB1AN...	.10	.38	.088	.068
T7XN....	.12	.34	.098	.048					
T7XN....	.12	.32	.121	.050	CB2XN...	.11	.40	.110	.082
T7XN....	.11	.28	.069	.049	CB2XN...	.13	.81	.102	.080
T7XNN...	.12	.27	.086	.031	CB2XN...	.13	.49	.100	.089
T7XNN...	.14	.26	.103	.043	CB2XNN.	.13	.54	.095	.085
					CB2ANN..	.11	.39	.119	.060
CT1XN...	.12	.31	.061	.040					
CT1AN...	.13	.35	.070	.059	CB3XNN.	.13	.40	.124	.069
CT1AN...	.11	.37	.068	.076	CB3XNN.	.11	.39	.103	.056
CT1ANN..	.13	.31	.061	.048					
					H1XN....	.13	.45	.109	.069
CT2XN...	.10	.23	.080	.052	H1XN....	.11	.47	.094	.063
CT2XN...	.12	.28	.079	.066	H1XN....	.11	.40	.106	.068
CT2XN...	.12	.31	.070	.064					
CT2XNN.	.09	.32	.060	.054	H2XN....	.11	.36	.105	.100
CT2XNN.	.12	.35	.059	.054	H2XN....	.12	.50	.113	.062
CT2XNN.	.12	.31	.052	.044	H2XN....	.12	.38	.130	.093
CT2ANN..	.12	.26	.092	.065	H2XN....	.13	.46	.114	.039
CT2ANN..	.12	.27	.072	.049	H2XN....	.11	.40	.082	.077
CT2ANN..	.13	.35	.074	.057	H2XN....	.11	.38	.110	.077
					H2XN....	.13	.43	.081	.036
CT3XN...	.12	.32	.111	.065	H2XNN...	.12	.45	.124	.064
CT3XN...	.11	.30	.089	.064	H2XNN...	.11	.39	.078	.090
CT3XN...	.10	.29	.105	.056					
CT3XN...	.12	.28	.085	.054	H3XN....	.11	.36	.083	.041
CT3XN...	.11	.27	.064	.043	H3XN....	.11	.49	.116	.060
CT3XNN.	.12	.31	.087	.060	H3XN....	.10	.33	.104	.075
CT3XNN.	.10	.33	.073	.045	H3XNN...	.11	.38	.130	.076

TABLE 83.—CARBON, MANGANESE, PHOSPHORUS AND SULPHUR CONTENT OF STEEL FROM PERFORATED CANS OF 1917 EXPERIMENTAL PACK.—*Continued.*

BLUEBERRIES.—*Continued.*

Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.	Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
H3AN....	0.11	0.35	0.077	0.061	CH3XN...	0.12	0.47	0.107	0.088
H3ANN...	.09	.40	.078	.067	CH3XN...	.12	.43	.111	.052
					CH3XN...	.12	.49	.098	.108
H4XN....	.09	.35	.087	.061	CH3XN...	.11	.50	.094	.083
H4XN....	.12	.38	.117	.070	CH3XNN.	.12	.53	.119	.068
H4XN....	.11	.34	.098	.080	CH3XNN.	.11	.49	.120	.100
H4XNN...	.12	.47	.102	.060	CH3XNN.	.10	.42	.100	.076
					CH3XNN.	.12	.43	.082	.054
CH1XN...	.12	.52	.105	.080	CH3XNN.	.12	.45	.118	.096
CH1XNN.	.14	.48	.107	.080	CH3XNN.	.11	.47	.081	.049
CH1XNN.	.14	.41	.081	.064	CH3XNN.	.12	.46	.120	.090
CH1XNN.	.12	.47	.091	.066	CH3XNN.	.11	.47	.137	.103
CH1AN...	.....	.38	.097	.092	CH3XNN.	.12	.46	.123	.094
CH1AN...	.12	.48	.123	.101	CH3XNN.	.12	.42	.134	.110
CH1ANN.	.11	.40	.087	.082	CH3XNN.	.11	.47	.097	.038
CH1ANN.	.13	.37	.095	.082	CH3XNN.	.11	.50	.107	.098
CH1ANN.	.12	.39	.099	.079					
					AR3XN...	.10	.35	.077	.047
CH2XN...	.13	.46	.088	.068	AR3XN...	.11	.34	.060	.037
CH2XN...	.11	.44	.102	.064	AR3XN...	.12	.36	.081	.048
CH2XNN.	.11	.49	.088	.063	AR3ANN.	.15	.39	.092	.054
CH2XNN.	.11	.50	.105	.064	AR3ANN.	.14	.36	.090	.052
CH2XNN.	.10	.47	.105	.066					
CH2XNN.	.12	.51	.100	.070	AT4XP...	.14	.31	.086	.044
CH2XNN.	.13	.47	.096	.068	AT4XN...	.14	.32	.098	.050
CH2XNN.	.13	.48	.131	.079	AT4XNN.	.15	.33	.095	.049
CH2AN...	.13	.45	.126	.102	AT4XNN.	.14	.32	.093	.049
CH2AN...	.13	.51	.076	.044	AT4AP...	.14	.34	.084	.044
CH2AN...	.12	.50	.082	.034	AT4AN...	.14	.34	.094	.053
CH2ANN.	.13	.47	.079	.068	AT4AN...	.12	.34	.095	.052
CH2ANN.	.12	.51	.065	.032					
CH2ANN.	.13	.49	.076	.037	SR3AN...	.12	.37	.078	.050
CH2ANN.	.14	.49	.120	.093					
CH2ANN.	.14	.51	.071	.033	ER3XN...	.12	.35	.086	.053
					ER3XN...	.13	.38	.097	.056
CH3XN...	.11	.45	.126	.102	ER3XNN.	.13	.35	.088	.054
CH3XN...	.12	.48	.123	.101					
CH3XN...	.10	.47	.074	.047	ET4XN...	.14	.32	.094	.047
CH3XN...	.12	.44	.104	.074	ET4XNN.	.15	.34	.091	.052
CH3XN...	.11	.40	.102	.059	ET4XNN.	.12	.33	.083	.039

STRAWBERRIES.

R1XNN...	0.11	0.34	0.090	0.063	CR2XN...	0.14	0.34	0.112	0.070
					CR2XNN.	.11	.34	.107	.063
R2XNN...	.12	.33	.118	.065	CR2XNN.	.12	.35	.139	.087
R2XNN...	.13	.34	.158	.085	CR2XNN.	.13	.33	.150	.087
R2XNN...	.14	.33	.134	.079	CR2AN...	.13	.31	.114	.068
R2ANN...	.10	.32	.111	.052	CR2AN...	.13	.31	.114	.068
					CR2AN...	.13	.30	.132	.068
R3XN....	.14	.35	.094	.056	CR2ANN.	.11	.34	.115	.072
R3XNN...	.11	.34	.091	.053	CR2ANN.	.11	.35	.121	.074
R3XNN...	.12	.37	.104	.064	CR2ANN.	.11	.34	.119	.069
R3XNN...	.13	.35	.090	.049	CR2ANN.	.14	.33	.138	.062
R3AN....	.14	.35	.115	.062	CR2ANN.	.14	.33	.170	.088
R3ANN...	.14	.33	.091	.050					
R3ANN...	.11	.25	.115	.080	CR3XN...	.13	.33	.085	.058
					CR3XNN.	.14	.35	.122	.066
R4XN....	.13	.35	.082	.036	CR3AN...	.13	.30	.132	.068
					CR3AN...	.13	.31	.091	.056
R5AN....	.10	.29	.096	.072	CR3ANN.	.12	.36	.088	.051
R5ANN...	.10	.24	.124	.058					
R5ANN...	.12	.26	.126	.078	CT2AN...	.12	.26	.068	.056
					CT2AN...	.12	.26	.076	.057
R6XNN...	.12	.40	.090	.066					
					CT3XN...	.12	.28	.065	.036
R7ANN...	.13	.33	.085	.053	CT3XN...	.11	.32	.082	.049
					CT3XNN.	.11	.29	.094	.061
CR1ANN.	.10	.33	.100	.070	CT3ANN..	.11	.29	.104	.060
CR1ANN.	.10	.34	.096	.060					

TABLE 83.—CARBON, MANGANESE, PHOSPHORUS AND SULPHUR CONTENT OF STEEL FROM PERFORATED CANS OF 1917 EXPERIMENTAL PACK.—*Continued.*

STRAWBERRIES.—*Continued.*

Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.	Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
H1ANN...	0.12	0.36	0.106	0.090	CB3XN...	0.12	0.41	0.148	0.075
H2XNN...	.10	.32	.079	.040					
H2XNN...	.11	.35	.108	.051	T1XNN...	.12	.33	.067	.055
H2XNN...	.11	.40	.089	.044	T1XNN...	.12	.34	.069	.066
H2XNN...	.11	.36	.110	.056					
H2AN....	.10	.36	.104	.075	T2XNN...	.11	.29	.081	.064
H2ANN...	.13	.40	.110	.085	T2XNN...	.11	.25	.075	.059
H4XNN...	.10	.32	.090	.059	T2XNN...	.11	.27	.077	.055
H4XNN...	.11	.31	.128	.080	T2XNN...	.12	.26	.102	.078
		.40			T2AN....	.12	.24	.080	.062
CH1XNN.	.10	.41	.109	.073	T2ANN...	.11	.28	.059	.047
CH1XNN.	.11		.095	.074	T2ANN...	.10	.28	.077	.066
CH1XNN.	.10	.34	.092	.061	T2ANN...	.10	.28	.079	.059
CH1ANN.	.11	.48	.103	.079					
CH1ANN.	.11	.37	.098	.079	T3XN....	.10	.26	.061	.042
CH2XNN.	.13	.45	.117	.069	T3XN....	.12	.29	.086	.049
CH2XNN.	.12	.44	.096	.069	T3XNN...	.12	.29	.097	.058
CH3XNN.	.11	.47	.130	.072	T3XNN...	.13	.35	.126	.063
					T3XNN...	.11	.30	.095	.049
B1XN....	.13	.38	.153	.073	T3AN....	.13	.29	.087	.051
B1XNN...	.13	.36	.123	.074	T3ANN...	.13	.30	.108	.058
B1XNN...	.09	.36	.103	.054	T3ANN...	.13	.34	.155	.079
B1XNN...	.12	.36	.124	.093	T3ANN...	.13	.30	.115	.059
					T3ANN...	.12	.29	.062	.040
B2XN....	.11	.38	.114	.088					
B2XN....	.11	.30	.076	.051	T4XN....	.12	.31	.097	.046
B2AN....	.12	.36	.113	.099	T4ANN...	.13	.31	.101	.061
B3XNN...	.12	.39	.109	.100	T7XNN...	.12	.29	.085	.040
					T7XNN...	.12	.29	.094	.044
B4XNN...	.14	.32	.123	.055	T7ANN...	.14	.30	.131	.050
					ST4AN...	.12	.34	.090	.050
CB1XN...	.10	.30	.117	.055	ST4AN....	.13	.31	.078	.053
CB1XN...	.12	.33	.148	.059					
CB1XN...	.11	.27	.131	.050	AR3XNN.	.12	.36	.087	.048
CB1XNN.	.12	.33	.123	.061	AR3ANN.	.14	.34	.082	.051
CB1XNN.	.11	.35	.100	.052					
CB1AN...	.13	.32	.104	.061	AT4XN...	.15	.31	.098	.046
CB1ANN..	.11	.37	.116	.078	AT4XN...	.14	.30	.094	.049
					AT4AN...	.13	.34	.110	.058
CB2XNN.	.11	.46	.107	.087	AT4AN...	.14	.31	.098	.046
CB2XNN.	.12	.46	.112	.083	AT4AN...	.13	.33	.103	.049
CB2XNN.	.12	.49	.106	.092	AT4ANN..	.15	.34	.134	.064
CB2AN...	.12	.39	.096	.076					
CB2ANN..	.12	.41	.098	.079	SR3AN...	.12	.35	.080	.050
CB2ANN..	.11	.41	.108	.089					

APPLES.

R2XP....	0.16	0.36	0.117	0.069	CR2AP...	0.13	0.36	0.098	0.068
R2AP.....	.12	.41	.120	.100	CR2AP...	.13	.30	.120	.066
R2AP.....	.17	.32	.117	.075					
					CR3XP...	.12	.35	.069	.042
R3XP....	.17	.34	.135	.094	CR3AP...	.15	.36	.082	.045
R3XP....	.12	.37	.079	.043	CR3AP...	.12	.33	.074	.052
R3XP....	.13	.35	.078	.052					
R3AP.....	.13	.35	.091	.052	CR7XP...	.12	.34	.077	.063
R4XP....	.15	.35	.079	.047					
R4XP....	.12	.34	.101	.051	T2XP.....	.13	.28	.076	.061
R4AP.....	.13	.34	.064	.041	T2XP.....	.13	.26	.096	.077
R4AP.....	.12	.34	.101	.058	T4XP.....	.16	.36	.094	.050
R4AP.....	.12	.32	.097	.055	T4XP.....	.14	.33	.103	.054
R4AP.....	.12	.35	.099	.055	T5AP.....	.13	.35	.104	.072
CR1XP...	.14	.35	.132	.091	T6AP.....	.12	.36	.061	.038
CR1XP...	.12	.48	.101	.061					
					T7AP.....	.11	.30	.086	.041
CR2XP...	.12	.31	.132	.087	T7AP.....	.13	.32	.105	.051
CR2AP...	.12	.33	.096	.060					

TABLE 83.—CARBON, MANGANESE, PHOSPHORUS AND SULPHUR CONTENT OF STEEL FROM PERFORATED CANS OF 1917 EXPERIMENTAL PACK.—*Continued.*

APPLES.—*Continued.*

Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.	Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
CT2XP...	0.13	0.31	0.086	0.053	B3XP.....	0.12	0.37	0.108	0.070
CT2AP...	.12	.30	.094	.097					
					CB1XP...	.13	.36	.099	.047
CT3XP...	.13	.31	.091	.068	CB1XP...	.12	.40	.092	.047
CT3XP...	.12	.29	.092	.063					
CT3AP...	.10	.31	.056	.039	CB2AP...	.12	.39	.100	.091
CT3AP...	.11	.31	.090	.083	CB2AP...	.12	.37	.113	.092
					CB2AP...	.12	.44	.123	.099
AT4XP...	.13	.33	.090	.059					
					CB3AP...	.14	.35	.080	.055
ET4XP...	.15	.33	.084	.047	CB3AP...	.13	.35	.081	.049
ET4AP...	.13	.30	.111	.082					

CIDER.

R1XP....	0.11	0.31	0.108	0.073	R5XN....	0.13	0.32	0.133	0.088
R1XP....	.11	.32	.107	.049	R5AN....	.12	.27	.097	.067
R1XP....	.12	.30	.070	.049	R5AN....	.12	.21	.121	.106
R1XP....	.12	.33	.095	.058	R5ANN...	.10	.32	.101	.059
R1XP....	.11	.30	.080	.045					
R1AP.....	.13	.30	.083	.057	R6XP.....	.11	.40	.065	.046
R1AP.....	.12	.32	.094	.049	R6XP....	.12	.38	.068	.053
R1AP.....	.12	.32	.092	.054	R6XP....	.10	.36	.077	.039
R1AN....	.12	.32	.089	.053	R6XN....	.12	.38	.099	.057
R1AN....	.12	.31	.077	.048	R6XNN...	.12	.37	.101	.064
R1AN....	.13	.33	.075	.048	R6XNN...	.14	.38	.096	.060
R1AN....	.12	.32	.069	.060	R6XNN...	.13	.37	.093	.053
R1ANN...	.13	.30	.084	.048	R6AP.....	.14	.34	.093	.065
R1ANN...	.10	.33	.086	.056	R6AP.....	.13	.35	.098	.067
R1ANN...	.13	.34	.074	.060	R6AP.....	.13	.33	.098	.068
R1ANN...	.12	.31	.075	.049	R6AP.....	.12	.36	.095	.066
					R6AP.....	.12	.34	.087	.065
R2XP....	.13	.32	.138	.094	R6AN....	.13	.41	.100	.078
R2XP....	.16	.29	.128	.074	R6AN....	.12	.38	.090	.037
R2XP....	.14	.38	.114	.085	R6ANN...	.13	.20	.106	.077
R2XP....	.15	.25	.125	.069	R6ANN...	.12	.39	.093	.053
R2XP....	.13	.37	.130	.095					
R2XP....	.14	.37	.140	.094	R7XNN...	.12	.35	.067	.057
R2XNN...	.13	.31	.116	.072	R7AN....	.11	.36	.086	.055
R2AP.....	.14	.35	.130	.079	R7ANN...	.13	.32	.100	.060
R2AP.....	.13	.34	.144	.099					
R2AP.....	.12	.30	.117	.070	CR1XN...	.10	.28	.079	.045
R2AP.....	.15	.38	.128	.083	CR1XN...	.11	.31	.103	.067
R2AP.....	.15	.33	.120	.075	CR1XN...	.13	.33	.093	.059
R2ANN...	.12	.33	.075	.054	CR1XN...	.12	.35	.085	.054
					CR1XNN.	.12	.30	.083	.047
R3XN....	.11	.29	.094	.067	CR1XNN.	.11	.33	.079	.059
R3XN....	.13	.39	.084	.052	CR1XNN.	.13	.32	.088	.060
R3XN....	.12	.35	.080	.040	CR1XNN.	.13	.31	.100	.068
R3XN....	.14	.36	.087	.049	CR1AP...	.12	.42	.099	.076
R3XN....	.13	.34	.079	.043	CR1AN...	.12	.32	.103	.069
R3XNN...	.15	.35	.082	.049	CR1AN...	.12	.32	.121	.079
R3XNN...	.13	.37	.086	.057	CR1AN...	.11	.30	.082	.049
R3XNN...	.14	.38	.090	.052	CR1AN...	.12	.32	.114	.076
R3AN....	.13	.37	.094	.055	CR1ANN.	.10	.31	.100	.053
R3AN....	.14	.34	.085	.063	CR1ANN.	.11	.30	.086	.054
					CR1ANN.	.11	.29	.059	.041
R4XNN...	.12	.36	.088	.053	CR1ANN.	.10	.31	.099	.067
R4XNN...	.14	.38	.082	.057					
R4AP.....	.14	.37	.094	.052	CR2XP...	.13	.33	.119	.070
R4ANN...	.11	.37	.102	.040	CR2XP...	.13	.38	.125	.087
R4ANN...	.14	.35	.112	.070	CR2XNN.	.12	.48	.101	.090
R4ANN...	.13	.34	.101	.065	CR2AP...	.10	.32	.130	.084
R4ANN...	.14	.34	.103	.065	CR2AP...	.14	.33	.117	.076
R4ANN...	.13	.35	.085	.050	CR2AP...	.13	.31	.112	.071
					CR2AP...	.14	.33	.121	.073
R5XN....	.11	.26	.090	.067	CR2AP...	.13	.32	.122	.073
R5XN....	.10	.26	.095	.072	CR2AN...	.11	.33	.124	.080
R5XN....	.12	.25	.080	.039					

TABLE 83.—CARBON, MANGANESE, PHOSPHORUS AND SULPHUR CONTENT OF STEEL FROM PERFORATED CANS OF 1917 EXPERIMENTAL PACK.—*Continued.*

CIDER.—*Continued.*

Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.	Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
CR3XN...	0.11	0.35	0.060	0.056	T7XNN...	0.12	0.36	0.083	0.039
CR3XNN.	.15	.39	.107	.060	T7XNN...	.12	.31	.081	.032
CR3AN...	.12	.33	.079	.044	T7AP.....	.12	.30	.098	.040
CR3AN...	.13	.34	.094	.055	T7AP.....	.12	.37	.100	.042
CR3AN...	.13	.39	.070	.057	T7ANN...	.12	.35	.091	.065
CR3AN...	.12	.35	.090	.056	T7ANN...	.13	.31	.112	.043
CR3AN...	.13	.37	.095	.056	T7ANN...	.13	.28	.102	.038
CR3ANN.	.12	.36	.076	.043	T7ANN...	.12	.29	.118	.041
					T7ANN...	.13	.31	.113	.038
T1XP.....	.11	.31	.082	.053	T7ANN...	.12	.33	.087	.038
T1XP.....	.13	.34	.049	.055	T7ANN...	.13	.31	.086	.039
T1XP.....	.12	.31	.047	.044	T7ANN...	.14	.31	.094	.047
T1XN.....	.13	.35	.066	.053	T7ANN...	.13	.31	.086	.039
T1XN.....	.12	.33	.068	.060	T7AN.....	.11	.30	.085	.049
T1XN.....	.12	.34	.056	.051	T7AN.....	.12	.30	.081	.037
T1XNN...	.13	.33	.056	.051					
T1XNN...	.13	.33	.064	.051	CT1XN...	.10	.24	.060	.050
T1XNN...	.12	.35	.124	.090	CT1XN...	.12	.32	.058	.051
T1XNN...	.12	.30	.066	.055	CT1XN...	.14	.36	.060	.082
T1XNN...	.13	.33	.046	.041	CT1XN...	.13	.32	.065	.063
T1XNN...	.12	.32	.061	.055	CT1XN...	.13	.36	.067	.057
T1XNN...	.13	.33	.060	.059	CT1XN...	.14	.37	.059	.056
T1XNN...	.14	.38	.068	.063	CT1XNN.	.12	.33	.063	.062
T1AP.....	.12	.36	.064	.060	CT1XNN.	.12	.32	.053	.050
T1ANN...	.13	.35	.078	.056	CT1XNN.	.12	.38	.050	.052
T1ANN...	.14	.37	.058	.057	CT1XNN.	.12	.37	.064	.076
					CT1ANN..	.12	.36	.056	.067
T2XN.....	.11	.29	.079	.071	CT1ANN.	.13	.38	.062	.061
T2XNN...	.13	.27	.079	.053					
T2AN.....	.12	.25	.085	.059	CT2XN...	.12	.26	.064	.058
T2AN.....	.10	.29	.071	.059	CT2XN...	.11	.24	.131	.053
T2AN.....	.13	.31	.074	.055	CT2XN...	.12	.26	.072	.059
T2AN.....	.10	.24	.059	.042	CT2XNN.	.12	.26	.062	.056
					CT2XNN.	.14	.25	.068	.058
T3AN.....	.12	.33	.085	.049	CT2XNN.	.10	.28	.061	.042
T3ANN...	.12	.32	.092	.063	CT2AN...	.09	.26	.070	.056
		.37			CT2AN...	.11	.27	.069	.056
T4ANN...	.15		.100	.055					
T4ANN...	.14	.35	.111	.061	CT3XNN.	.11	.28	.081	.042
T4ANN...	.14	.35	.104	.057	CT3XNN.	.12	.30	.089	.053
T4ANN...	.15	.36	.101	.049	CT3XNN.	.11	.32	.076	.047
					CT3AP...	.11	.28	.078	.061
T5XNN...	.14	.36	.117	.071	CT3AN...	.10	.31	.066	.044
T5XNN...	.11	.39	.098	.070	CT3AN...	.12	.31	.081	.060
T5AN.....	.13	.37	.106	.042	CT3ANN..	.10	.31	.096	.060
T5AN.....	.13	.37	.108	.057	CT3ANN..	.12	.32	.102	.064
T5ANN...	.13	.34	.097	.058					
T5ANN...	.12	.36	.113	.067	CT6XN...	.13	.33	.062	.067
T6XP.....	.13	.29	.095	.053	H1XP.....	.12	.35	.118	.071
T6XP.....	.11	.36	.098	.058	H1XP.....	.15	.45	.114	.077
T6XN.....	.12	.33	.068	.060	H1XN.....	.12	.47	.121	.069
T6XNN...	.13	.33	.095	.059	H1XN.....	.12	.47	.105	.076
T6XNN...	.13	.33	.097	.060	H1XN.....	.13	.45	.114	.063
T6XNN...	.13	.33	.095	.063	H1XN.....	.14	.44	.113	.076
T6XNN...	.14	.32	.093	.051	H1XN.....	.12	.44	.122	.096
T6AP.....	.13	.35	.112	.077	H1XNN...	.12	.47	.089	.059
T6AP.....	.14	.44	.118	.073	H1XNN...	.11	.46	.100	.061
T6AN.....	.12	.34	.098	.063	H1XNN...	.12	.44	.113	.060
T6ANN...	.11	.31	.090	.058	H1XNN...	.12	.47	.113	.064
T6ANN...	.13	.30	.096	.058	H1AN.....	.11	.38	.101	.074
T6ANN...	.12	.32	.100	.067					
T6ANN...	.13	.44	.089	.065	H2XN.....	.11	.36	.079	.051
T6ANN...	.10	.32	.094	.067	H2XN.....	.12	.36	.112	.090
T6ANN...	.13	.34	.110	.069	H2XN.....	.14	.41	.086	.039
T6ANN...	.12	.34	.099	.050	H2XNN...	.11	.37	.108	.055
T6ANN...	.13	.33	.090	.056	H2XNN...	.14	.34	.091	.054
					H2XNN...	.11	.36	.066	.041
T7XN.....	.12	.23	.079	.034	H2XNN...	.13	.34	.095	.052
T7XN.....	.12	.31	.079	.032	H2XNN...	.12	.36	.098	.092
T7XNN...	.11	.30	.095	.045	H2XNN...	.12	.40	.057	.048

TABLE 83.—CARBON, MANGANESE, PHOSPHORUS AND SULPHUR CONTENT OF STEEL FROM PERFORATED CANS OF 1917 EXPERIMENTAL PACK.—*Continued.*

CIDER.—*Continued.*

Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.	Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
H2XNN...	0.13	0.35	0.108	0.052	B1XP.....	0.13	0.36	0.104	0.068
H2XNN...	.13	.48	.096	.043	B1XP.....	.13	.37	.112	.075
H2AN....	.12	.37	.107	.085	B1XN....	.13	.40	.109	.076
H2AN....	.13	.41	.074	.072	B1XN....	.12	.35	.077	.049
H2AN....	.12	.36	.105	.095	B1XN....	.12	.37	.116	.075
H2AN....	.12	.33	.111	.089	B1XNN...	.12	.40	.103	.064
H2ANN...	.12	.41	.085	.081	B1XNN...	.12	.39	.072	.046
H2ANN...	.14	.48	.085	.042	B1XNN...	.10	.44	.068	.036
					B1XNN...	.11	.36	.124	.080
H3XN....	.12	.34	.092	.051	B1AN....	.11	.43	.090	.059
H3AN....	.09	.36	.099	.064					
H3AN....	.12	.34	.112	.073	B2XP.....	.12	.37	.071	.080
H3AN....	.13	.45	.103	.073	B2XP.....	.12	.37	.107	.090
H3ANN...	.12	.38	.091	.041	B2XN....	.10	.32	.107	.102
H3ANN...	.09	.40	.108	.075	B2XNN...	.10	.31	.113	.091
					B2XNN...	.10	.32	.134	.092
H4XN....	.12	.32	.111	.072	B3XN....	.12	.47	.112	.097
H4XNN...	.10	.31	.089	.057	B3XN....	.13	.31	.134	.090
H4XNN...	.11	.36	.106	.070	B3XN....	.13	.41	.103	.074
H4XNN...	.11	.31	.094	.060					
					CB1XP...	.11	.37	.095	.051
CH1XP...	.12	.44	.098	.056	CB1XN...	.11	.39	.103	.061
CH1XN...	.12	.50	.077	.059	CB1XN...	.12	.36	.112	.064
CH1XN...	.12	.34	.074	.059	CB1XNN.	.12	.34	.102	.052
CH1XNN.	.11	.40	.095	.082	CB1XNN.	.12	.34	.096	.050
CH1XNN.	.11	.45	.096	.072	CB1XNN.	.13	.37	.103	.052
CH1XNN.	.11	.41	.105	.059	CB1AN...	.11	.39	.106	.073
CH1XNN.	.12	.35	.135	.086	CB1ANN..	.11	.34	.096	.077
CH1XNN.	.12	.43	.115	.063	CB1ANN..	.12	.36	.104	.052
CH1AP...	.11	.38	.103	.086					
CH1AN...	.11	.40	.104	.079	CB2AN...	.11	.37	.104	.086
CH1AN...	.12	.40	.107	.071	CB2ANN .	.12	.42	.099	.051
CH1AN...	.12	.40	.111	.088	CB2ANN..	.12	.40	.110	.103
CH1ANN.	.12	.40	.101	.086	CB2ANN..	.13	.46	.102	.095
CH1ANN.	.11	.38	.087	.082	CB2ANN..	.14	.39	.110	.094
CH1ANN.	.11	.40	.095	.082	CB2ANN..	.14	.40	.116	.095
CH1ANN.	.11	.41	.094	.076					
CH1ANN.	.11	.37	.091	.074	CB3XN...	.11	.38	.093	.061
CH1ANN.	.12	.41	.104	.077	CB3XN...	.11	.31	.106	.061
CH1ANN.	.10	.39	.097	.076	CB3XNN.	.12	.38	.112	.062
CH1ANN.	.13	.40	.100	.081	CB3XNN.	.13	.36	.107	.066
					CB3XNN.	.12	.38	.110	.094
CH2XNN.	.11	.49	.080	.060					
CH2XNN.	.13	.44	.101	.065	AR3XNN.	.12	.35	.062	.040
CH2XNN.	.12	.43	.097	.068	AR3XNN.	.13	.36	.066	.040
CH2XNN.	.12	.40	.111	.088	AR3XNN.	.11	.34	.086	.051
CH2AN...	.14	.45	.073	.042	AR3XN...	.11	.39	.080	.049
CH2AN...	.13	.51	.083	.045	AR3XN...	.10	.40	.058	.038
CH2AN...	.14	.52	.081	.048	AR3XN...	.13	.37	.085	.051
CH2AN...	.13	.54	.096	.043	AR3AP...	.10	.40	.074	.051
CH2AN...	.13	.49	.078	.044	AR3AN...	.13	.37	.075	.037
CH2AN...	.13	.51	.088	.045	AR3AN...	.15	.37	.100	.060
CH2AN...	.13	.49	.089	.050	AR3ANN.	.15	.36	.111	.064
CH2AN...	.14	.51	.103	.049	AR3ANN.	.15	.38	.093	.052
CH2AN...	.14	.50	.094	.046	AR3ANN.	.14	.37	.088	.052
CH2AN...	.14	.52	.094	.046					
CH2ANN.	.14	.50	.074	.038	AT4XN...	.14	.32	.063	.066
CH2ANN.	.13	.45	.087	.047	AT4XN...	.12	.36	.095	.050
CH2ANN.	.13	.51	.092	.046	AT4XNN.	.15	.33	.099	.057
CH2ANN.	.14	.52	.091	.048	AT4XNN.	.14	.32	.092	.050
					AT4AP...	.16	.34	.112	.052
CH3XP...	.11	.43	.118	.084	AT4AN...	.14	.37	.113	.057
CH3XP...	.11	.52	.123	.091	AT4ANN..	.15	.33	.098	.054
CH3XP...	.11	.46	.126	.096	AT4ANN..	.13	.33	.086	.043
					AT4ANN .	.14	.37	.104	.052
CH4ZN....	.12	.37	.104	.065	AT4ANN..	.15	.38	.117	.055
CH4ZNN..	.11	.34	.093	.056					
CH4ZNN..	.13	.40	.111	.086	ST4AN...	.13	.38	.085	.043
					ST4AN...	.12	.31	.100	.085
B1XP.....	.13	.41	.126	.071	ST4AN...	.13	.31	.098	.049
B1XP.....	.12	.35	.109	.067	ST4ANN..	.13	.31	.100	.049

TABLE 83.—CARBON, MANGANESE, PHOSPHORUS AND SULPHUR CONTENT OF STEEL FROM PERFORATED CANS OF 1917 EXPERIMENTAL PACK.—*Continued.*

CIDER.—*Continued.*

Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.	Cans.	Carbon.	Manganese.	Phosphorus.	Sulphur.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
ST4ANN..	0.13	0.32	0.106	0.052	ER3XNN.	0.13	0.33	0.089	0.054
					ER3XNN.	.10	.36	.072	.049
ER3XN...	.13	.34	.066	.055	ER3XNN.	.12	.35	.093	.056
ER3XNN.	.14	.35	.088	.053	ER3XNN.	.13	.36	.084	.049
ER3XNN.	.13	.32	.073	.048					
ER3XNN.	.14	.35	.070	.047	SR3AN...	.13	.44	.090	.056

APPENDIX XVIII.—DATA ON COMMERCIAL TIN PLATE.

TABLE 84.—DESCRIPTION OF COMMERCIAL TIN PLATE USED IN 1917 EXPERIMENT.

Lot designation.	Mill.	Steel.	Coating.	Pounds per base box.
H1X	A	Open-hearth	Coke	100
H1A	B	do	Charcoal	100
CH1X	C	Open-hearth, copper-bearing	Coke	100
CH1A	B	do	Charcoal	100
H2X	D	Open-hearth	Coke	100
H2A	B	do	Charcoal	100
CH2X	C	Open-hearth, copper-bearing	Coke	100
CH2A	E	do	Charcoal	90
H3X	F	Open-hearth	Coke	100
H3A	F	do	Charcoal	100
CH3X	D	Open-hearth, copper-bearing	Coke	100
H4X	J	Open-hearth	do	100
CH4Z	F	Open-hearth, copper-bearing	3A charcoal	100
B1X	F	Bessemer	Coke	100
B1A	B	do	Charcoal	100
CB1X	B	Bessemer, copper-bearing	Coke	100
CB1A	B	do	Charcoal	100
B2X	D	Bessemer	Coke	100
B2A	B	do	Charcoal	100
CB2X	H	Bessemer, copper-bearing	Coke	100
CB2A	B	do	Charcoal	100
B3X	I	Bessemer	Coke	100
CB3X	B	Bessemer, copper-bearing	do	100
B4X	C	Bessemer	do	100

TABLE 85.—COPPER CONTENT OF COMMERCIAL PLATE USED IN 1917.

PURCHASED AS NON-COPPER-BEARING.

Sample No.	Bessemer.						Open-hearth.						
	B1X.	B2X.	B3X.	B4X.	B1A.	B2A.	H1X.	H2X.	H3X.	H4X.	H1A.	H2A.	H3A.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1	None	None	None	None	None	None	None	0.27	None	None	None	0.24	0.26
2	do.	do.	do.	do.	do.	do.	.19	None	.....	do.	do.	.29	None
3	do.	do.	do.	do.	do.	do.	None	do.	.....	.....	do.	.27	do.
4	do.	.....	do.	do.	do.	do.	.15	do.	.....	.....	do.	.26	.26
5	do.	.....	do.	do.	do.	do.	.16	do.	.....	.....	do.	.29	.24
6	do.	.....	do.	do.	do.	do.	None	do.	.....	.....	do.	.24	.....
7	do.	.....	do.	do.	do.	do.	.16	.....	.....	.....	do.	.23	.....
8	do.	.....	do.	do.	do.	.....	.15	.....	.....	.....	do.	.23	.....
9	do.	.....	do.	do.	do.	.....	None	.....	.....	.....	do.	.28	.....
10	.....	.....	.....	.....	do.	.....	.....	.....	.....	.....	.....	.....	.....
11	.....	.....	.....	.....	do.	.....	.....	.....	.....	.....	.....	.....	.....
12	.....	.....	.....	.....	do.	.....	.....	.....	.....	.....	.....	.....	.....

PURCHASED AS COPPER-BEARING.

Sample No.	Bessemer.					Open-hearth.					
	CB1X.	CB2X.	CB3X.	CB1A.	CB2A.	CH1X.	CH2X.	CH3X.	CH1A.	CH2A.	CH4Z.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1	0.25	None	0.27	0.25	0.25	None	0.25	0.33	0.06	0.25	0.27
2	.27	do.	.29	.27	.23	do.	.23	.33	.15	.29	.25
3	None	do.	.....	.25	.23	do.	.31	.33	.25	.25	.27
4	.27	do.	.....	None	.08	do.	.....	.30	.19	.25	.27
5	.25	do.	.....	do.	.27	do.	.....	.30	.27	.....	.27
6	.25	do.	.....	do.	.23	do.	.....	.33	.27	.....	None
7	.27	do.	.....	.27	.23	do.	.....	.29	.28	.....	.25
8	.25	do.	.....	.27	.....	do.	.....	.33	.25	.....	.23
9	None	do.	.....	.25	.....	do.	.....	.31	.25	.....	.27
10	.27	.....	.....	.25	.....	.....	.....	.....	.25	.....	.....
11	.25	.....	.....	.25	.....	.....	.....	.....	.25	.....	.....
12	None	.....	.....	.25	.....	.....	.....	.....	.25	.....	.....
13	.....	.....	.....	.25	.....	.....	.....	.....	.25	.....	.....
14	.....	.....	.....	.25	.....	.....	.....	.....	.27	.....	.....
15	.....	.....	.....	.....	.....	.....	.....	.....	.27	.....	.....

APPENDIX XIX.—WEIGHT OF COATING ON CANS OF 1919 TIN PLATE.

TABLE 86.—WEIGHT OF TIN COATING ON INDIVIDUAL CANS OF 1919 EXPERIMENTAL PLATE.

Sample No.	R21.	R22.	R24.	CR21.	CR22.	CR24.	SR21.	SR22.	SR23.	SR24.	SCR21.	SCR22.	SCR23.
	Lbs. per base box.	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*
1.....	1.66	1.48	1.43	1.38	1.33	1.14	2.43	2.28	1.73	3.67	1.59	1.59	2.05
2.....	1.37	1.39	1.63	1.30	1.35	1.55	1.62	1.81	1.76	1.81	1.59	1.29	2.05
3.....	1.55	1.68	1.90	1.32	1.28	1.44	1.33	2.03	1.47	2.40	1.43	2.45	1.90
4.....	2.02	1.40	1.93	1.46	.....	1.25	1.58	2.02	1.39	1.97	1.53	1.50	1.30
5.....	1.57	1.52	1.25	1.28	.....	1.37	1.66	1.71	1.12	2.16	1.85	1.44	1.40
6.....	1.77	1.51	2.09	2.10	.....	1.30	.....	1.93	2.06	3.19	1.64	1.40	.97
7.....	1.55	1.90	2.38	1.98	.....	2.05	.....	1.32	1.52	2.40	1.30	1.40	.....
8.....	1.44	1.44	1.60	1.70	.....	1.70	.....	1.56	1.62	2.62	1.27	1.56	.....
9.....	1.23	1.93	1.14	1.47	.....	1.72	.....	1.48	1.43	.....	1.62	1.34	.....
10.....	1.20	1.62	.....	1.52	.....	1.27	.....	1.94	.....	.....	1.42	1.96	.....
11.....	1.39	1.48	.....	1.52	.....	2.28	.....	1.44	.....	.....	1.61	1.86	.....
12.....	1.77	1.14	.....	1.46	.....	1.41	.....	.....	.....	.....	1.51	.....	.....
13.....	.....	1.42	.....	1.74	.....	1.42	.....	.....	.....	.....	.....	.....	.....
14.....	.....	1.45	.....	1.58	.....	1.56	.....	.....	.....	.....	.....	.....	.....
15.....	.....	.....	.....	1.48	.....	1.60	.....	.....	.....	.....	.....	.....	.....
16.....	.....	.....	.....	.....	.....	1.30	.....	.....	.....	.....	.....	.....	.....
17.....	.....	.....	.....	.....	.....	1.81	.....	.....	.....	.....	.....	.....	.....
18.....	.....	.....	.....	.....	.....	1.74	.....	.....	.....	.....	.....	.....	.....
19.....	.....	.....	.....	.....	.....	1.40	.....	.....	.....	.....	.....	.....	.....
20.....	.....	.....	.....	.....	.....	1.62	.....	.....	.....	.....	.....	.....	.....
21.....	.....	.....	.....	.....	.....	1.46	.....	.....	.....	.....	.....	.....	.....
22.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
23.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Sample No.	SCR24.	T21.	T22.	T24.	CT21.	CT23.	CT24.	ST22.	ST23.	ST24.	SCT21.	SCT22.	SCT23.
	Lbs. per base box.	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*	*Lbs. per base box.*
1.....	1.61	1.15	1.70	1.79	1.53	1.68	1.61	1.22	1.54	2.28	1.08	1.40	1.14
2.....	1.30	1.28	1.45	1.73	1.61	1.71	1.63	1.28	1.66	2.93	1.71	1.26	1.62
3.....	1.59	1.47	1.44	1.95	1.55	1.26	1.92	1.22	1.87	1.73	1.86	1.74	1.74
4.....	1.60	1.20	1.71	2.20	1.27	1.51	1.81	1.25	1.70	2.85	.....	1.42	1.55
5.....	1.49	1.35	1.70	1.71	1.66	1.57	1.81	1.40	1.71	2.30	.....	1.40	1.73
6.....	1.28	1.40	1.71	.....	2.28	1.73	1.40	1.40	1.52	1.58	.....	1.42	1.51
7.....	1.82	1.39	.....	.....	1.49	.....	1.73	.....	1.93	2.23	.....	1.30	1.64
8.....	1.74	1.52	.....	.....	1.39	.....	1.50	.....	1.95	2.40	.....	1.27	1.39
9.....	1.58	1.56	.....	.....	1.42	.....	1.64	.....	1.25	2.44	.....	1.52	2.54
10.....	1.43	1.82	.....	.....	.....	.....	.....	.....	.....	2.75	.....	1.34	1.73
11.....	1.47	1.65	.....	.....	.....	.....	.....	.....	.....	2.48	.....	1.78	1.53
12.....	1.43	1.22	.....	.....	.....	.....	.....	.....	.....	2.62	.....	1.37	1.42
13.....	1.83	1.18	.....	.....	.....	.....	.....	.....	.....	3.05	.....	1.35	1.40
14.....	1.56	1.32	.....	.....	.....	.....	.....	.....	.....	2.01	.....	1.34	1.84
15.....	1.27	1.49	.....	.....	.....	.....	.....	.....	.....	1.98	.....	1.56	.....
16.....	1.67	.....	.....	.....	.....	.....	.....	.....	.....	1.97	.....	1.53	.....
17.....	1.87	.....	.....	.....	.....	.....	.....	.....	.....	1.48	.....	1.53	.....
18.....	1.45	.....	.....	.....	.....	.....	.....	.....	.....	1.84	.....	1.25	.....
19.....	1.73	.....	.....	.....	.....	.....	.....	.....	.....	2.28	.....	1.55	.....
20.....	1.63	.....	.....	.....	.....	.....	.....	.....	.....	2.36	.....	.....	.....
21.....	1.69	.....	.....	.....	.....	.....	.....	.....	.....	1.71	.....	.....	.....
22.....	2.09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
23.....	1.69	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

APPENDIX XX.—PHOSPHORUS CONTENT OF CANS OF 1919 TIN PLATE.

TABLE 87.—PHOSPHORUS CONTENT OF REPRESENTATIVE CANS OF 1919 EXPERIMENTAL PLATE.

REGULAR.

Can No.	R21.			R22.			R23.			R24.		
	End.	End.	Body.	End.	End.	Body.	End.	End.	Body.	End.	End.	Body.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1	0.064	0.061	0.054	0.092	0.090	0.086	0.063	0.072	0.069	0.092	0.097	0.107
2	.063	.051	.048	.087	.088	.095	.066	.075	.073	.088	.097	.101
3	.060	.058	.046	.091	.091	.094	.065	.069	.069	.092	.096	.103
4	.059	.053	.054	.098	.095	.095	.063	.054	.076	.095	.096	.110
5	.058	.038	.041	.089	.092	.077	.069	.061	.075	.089	.091	.092
6	.048	.060	.056	.086	.100	.085	.052	.078	.075	.094	.091	.094
7	.063	.064	.047	.094	.092	.080	.077	.074	.075	.083	.099	.113
8	.056	.046	.051	.087	.100	.069	.073	.073	.074	.088	.102	.108
9	.055	.058	.058	.097	.080	.086	.074	.050	.072	.089	.098	.110
10	.059	.045	.051	.094	.090	.089	.072	.066	.070	.092	.092	.116
11	.060	.046	.054	.087	.094	.095	.053	.073	.077	.088	.099	.111
12	.065	.056	.058	.092	.094	.094	.075	.083	.063	.096	.092	.112
13	.060	.060	.045	.087	.091	.089	.072	.066	.070	.098	.097	.110
14	.066	.051	.054	.090	.095	.089	.069	.072	.080	.098	.092	.113
15	.064	.055	.049	.090	.095	.096	.074	.066	.067	.099	.097	.098
16	.048	.061	.045	.097	.086	.065	.052	.062	.075	.106	.078	.116
17	.058	.043	.049	.091	.058	.087	.055	.068	.074	.106	.100	.105
18	.041	.058	.056	.097	.095	.094	.068	.073	.072	.100	.101	.104
19	.065	.061	.048	.094	.094	.080	.070	.074	.074	.098	.100	.096
20	.060	.056	.041	.090	.091	.094	.067	.051	.063	.100	.098	.096
21	.064	.054	.050	.086	.090	.077	.054	.073	.076	.094	.095	.099
22	.041	.057	.051	.090	.095	.084	.073	.058	.063	.099	.098	.106
23	.060	.042	.061	.095	.094	.092	.070	.075	.078	.102	.097	.100
24	.060	.047	.054	.096	.098	.087	.067	.064	.073	.099	.097	.098
25	.064	.058	.055	.085	.096	.085	.070	.065	.069	.108	.098	.097
26	.065	.060	.061	.101	.095	.095	.051	.066	.074	.096	.092	.098
27	.055	.057	.051	.090	.090	.090	.061	.051	.075	.107	.096	.098
28	.056	.059	.060	.096	.088	.088	.073	.073	.075	.103	.097	.107
29	.053	.056	.060	.092	.094	.094	.064	.074	.074	.101	.101	.096
30	.058	.056	.056	.091	.097	.091	.069	.076	.057	.110	.096	.103
31	.063	.057	.059	.075	.090	.091	.054	.074	.072	.106	.105	.095
32	.058	.057	.058	.095	.090	.093	.066	.081	.058	.106	.096	.108

TABLE 87.—PHOSPHORUS CONTENT OF REPRESENTATIVE CANS OF 1919 EXPERIMENTAL PLATE.—*Continued.*

TITANIUM-TREATED.

Can No.	T21.			T22.			T23.			T24.		
	End.	End.	Body.	End.	End.	Body.	End.	End.	Body.	End.	End.	Body.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1	0.045	0.049	0.035	0.071	0.066	0.073	0.047	0.068	0.077	0.079	0.070	0.077
2	.041	.034	.039	.073	.071	.071	.061	.063	.067	.078	.084	.080
3	.031	.039	.038	.071	.077	.051	.068	.069	.066	.076	.084	.080
4	.044	.046	.043	.069	.083	.050	.051	.059	.077	.076	.078	.079
5	.035	.029	.043	.051	.072	.073	.076	.070	.079	.079	.083	.074
6	.034	.050	.040	.073	.070	.070	.076	.046	.083	.063	.067	.073
7	.039	.036	.034	.065	.071	.073	.087	.077	.079	.078	.080	.081
8	.038	.036	.036	.068	.076	.076	.078	.079	.091	.086	.083	.072
9	.044	.055	.035	.061	.074	.067	.056	.061	.062	.073	.082	.077
10	.036	.049	.026	.062	.069	.075	.101	.079	.097	.076	.075	.083
11	.035	.035	.038	.078	.079	.072	.076	.068	.064	.077	.089	.080
12	.046	.030	.033	.075	.074	.062	.074	.072	.072	.076	.084	.078
13	.043	.055	.040	.075	.071	.071	.064	.059	.078	.080	.078	.079
14	.050	.049	.044	.076	.073	.073	.073	.065	.070	.073	.079	.075
15	.045	.032	.038	.072	.072	.070	.080	.080	.072	.072	.079	.074
16	.045	.042	.038	.072	.069	.069	.069	.088	.066	.079	.077	.083
17	.045	.042	.044	.075	.080	.068	.066	.059	.072	.083	.076	.078
18	.040	.051	.042	.069	.077	.061	.063	.058	.068	.089	.077	.081
19	.041	.034	.047	.071	.072	.063	.062	.048	.067	.081	.077	.080
20	.044	.045	.041	.075	.069	.074	.058	.065	.059	.072	.077	.077
21	.042	.034	.046	.069	.074	.075	.058	.058	.066	.080	.085	.081
22	.043	.046	.045	.075	.071	.067	.065	.061	.064	.084	.079	.079
23	.045	.032	.040	.072	.073	.058	.062	.063	.058	.076	.076	.074
24	.043	.031	.045	.070	.086	.071	.052	.063	.057	.079	.083	.078
25	.041	.039	.044	.072	.088	.075	.061	.061	.059	.078	.080	.078
26	.048	.045	.041	.075	.072	.068	.055	.068	.055	.073	.081	.080
27	.046	.043	.042	.073	.080	.071	.062	.059	.074	.076	.077	.081
28	.035	.044	.040	.073	.061	.067	.058	.055	.061	.082	.078	.086
29	.033	.047	.043	.066	.077	.079	.061	.055	.064	.078	.079	.079
30	.045	.037	.044	.071	.067	.070	.054	.063	.056	.079	.078	.080
31	.041	.043	.035	.065	.072	.070	.064	.061	.055	.083	.081	.084
32	.051	.042	.041	.073	.074	.067	.....	.....	.....	.080	.077	.079

NOTE.—Separate determinations were made on each end of each can.

APPENDIX XXI.—ERICHSEN TESTS ON 1919 TIN PLATE.

TABLE 88.—RESULTS OF ERICHSEN TESTS OF TIN PLATE, 1919 EXPERIMENT.

Regular steel.							Titanium-treated steel						
Plate and location of test piece.	Thickness.	Observed Erichsen No.	Average. Thickness.	Average. Erichsen No.	Standard Erichsen No. for given thickness.	Per cent of standard.	Plate and location of test piece.	Thickness.	Observed Erichsen No.	Average. Thickness.	Average. Erichsen No.	Standard Erichsen No. for given thickness.	Per cent of standard.
	Mm.		*Mm.*					*Mm.*		*Mm.*			
R21:							T21:						
Edge	0.27	6.92	0.28	6.82	6.87	99.3	Edge	0.26	7.09	0.26	6.89	6.70	102.8
Midway between	.28	6.89					Midway between	.25	6.71				
Center	.29	6.64					Center	.26	6.85				
CR21:							CT21:						
Edge	.26	7.05	.26	6.98	6.70	104.2	Edge	.26	7.66	.26	7.59	6.70	113.3
Midway between	.26	6.93					Midway between	.26	7.52				
Center	.27	6.96					Center	.27	7.61				
SR21:							ST21:						
Edge	.26	7.32	.26	7.12	6.70	106.3	Edge	.26	7.29	.26	7.26	6.70	108.2
Midway between	.26	6.76					Midway between	.26	7.33				
Center	.26	7.27					Center	.27	7.17				
SCR21:							SCT21:						
Edge	.25	6.90	.26	7.09	6.70	105.8	Edge	.26	6.61	.26	6.65	6.70	99.3
Midway between	.26	7.30					Midway between	.25	6.47				
Center	.27	7.08					Center	.27	6.87				
R22:							T22:						
Edge	.26	7.27	.26	7.21	6.70	107.6	Edge	.25	7.43	.25	7.22	6.60	109.4
Midway between	.26	7.10					Midway between	.24	7.23				
Center	.27	7.25					Center	.25	7.01				
CR22:							CT22:						
Edge	.27	7.47	.27	7.20	6.75	106.7	Edge	.25	7.44	.26	7.17	6.70	107.0
Midway between	.27	6.82					Midway between	.27	7.15				
Center	.26	7.31					Center	.26	6.86				
SR22:							ST22:						
Edge	.26	7.32	.26	6.89	6.70	102.8	Edge	.26	7.24	.26	7.34	6.70	109.5
Midway between	.25	6.74					Midway between	.25	7.20				
Center	.26	6.61					Center	.28	7.59				
SCR22:							SCT22:						
Edge	.26	7.31	.26	7.28	6.70	108.7	Edge	.25	7.23	.26	7.26	6.70	108.4
Midway between	.26	7.28					Midway between	.26	7.37				
Center	.26	7.25					Center	.26	7.18				

R23:						
Edge	0.25	7.96				
Midway between	.26	7.69	.25	7.87	6.60	119.2
Center	.25	7.98				
CR23:						
Edge	.25	7.05				
Midway between	.25	6.93	.25	7.08	6.60	107.3
Center	.25	7.27				
SR23:						
Edge	.26	6.69				
Midway between	.25	6.76	.26	6.83	6.70	101.9
Center	.26	7.09				
SCR23:						
Edge	.26	7.02				
Midway between	.26	7.13	.26	7.04	6.70	105.1
Center	.26	6.96				
R24:						
Edge	.25	7.61				
Midway between	.26	7.70	.26	7.67	6.70	114.5
Center	.26	7.71				
CR24:						
Edge	.25	7.22				
Midway between	.26	6.66	.26	6.89	6.70	102.8
Center	.26	7.01				
SR24:						
Edge	.26	7.00				
Midway between	.26	6.75	.26	6.74	6.70	100.6
Center	.26	6.49				
SCR24:						
Edge	.28	6.72				
Midway between	.28	6.86	.28	6.81	6.87	99.1
Center	.27	6.86				
T23:						
Edge	0.26	7.71				
Midway between	.26	7.26	.26	7.63	6.70	113.9
Center	.27	7.92				
CT23:						
Edge	.25	7.29				
Midway between	.26	7.18	.26	7.22	6.70	107.8
Center	.27	7.18				
ST23:						
Edge	.25	7.21				
Midway between	.25	7.04	.25	7.04	6.60	106.7
Center	.25	6.87				
SCT23:						
Edge	.26	6.94				
Midway between	.26	6.89	.26	6.97	6.70	104.0
Center	.26	7.10				
T24:						
Edge	.26	7.12				
Midway between	.26	7.30	.26	7.28	6.70	108.7
Center	.26	7.42				
CT24:						
Edge	.25	6.55				
Midway between	.26	6.75	.25	6.63	6.60	100.5
Center	.25	6.59				
ST24:						
Edge	.26	6.61				
Midway between	.25	6.66	.25	6.55	6.60	99.2
Center	.25	6.40				
SCT24:						
Edge	.26	6.27				
Midway between	.27	6.40	.27	6.44	6.75	95.4
Center	.27	6.66				

NOTE.—Tests were made in triplicate, so that the reading at each location is really the average from three sheets

APPENDIX XXII.—BENDING TESTS ON 1919 TIN PLATE.

TABLE 89.—RESULTS OF BENDING TESTS OF TIN PLATE, 1919 EXPERIMENT.

Regular steel.					Titanium-treated steel.				
Sheets.	Number of bends.[a]			Ratio.[b]	Sheets.	Number of bends.[a]			Ratio.[b]
	Transverse.	Lengthwise.	Average.			Transverse.	Lengthwise.	Average.	
R21	13, 10	23, 19	16.2	0.55	T21	18, 15	26, 19	19.5	0.73
CR21	15, 11	17, 13	14.0	.87	CT21	13, 13	15, 14	13.8	.90
SR21	8, 8	20, 15	12.8	.46	ST21	10, 9	17, 14	12.5	.61
SCR21	7, 7	11, 13	9.5	.54	SCT21	12, 10	18, 13	13.2	.71
R22	18, 11	22, 19	17.5	.71	T22	12, 12	25, 18	16.8	.56
CR22	13, 8	19, 19	14.8	.55	CT22	10, 7	19, 18	13.5	.46
SR22	7, 7	18, 13	11.2	.45	ST22	11, 11	22, 21	16.0	.51
SCR22	9, 4	12, 12	9.2	.54	SCT22	9, 11	14, 15	12.2	.69
R23	11, 12	29, 23	18.8	.44	T23	13, 12	15, 18	14.5	.76
CR23	13, 12	16, 16	14.2	.78	CT23	18, 11	22, 21	18.0	.67
SR23	7, 10	14, 17	12.0	.55	ST23	8, 8	18, 18	12.8	.44
SCR23	6, 10	14, 14	11.0	.57	SCT23	8, 8	17, 18	13.0	.46
R24	9, 10	23, 20	15.5	.44	T24	13, 10	25, 16	16.0	.56
CR24	10, 8	22, 19	14.8	.44	CT24	12, 10	24, 25	17.8	.45
SR24	6, 6	19, 22	13.2	.29	ST24	7, 6	18, 15	11.5	.39
SCR24	5, 8	12, 12	9.2	.54	SCT24	10, 5	21, 17	13.2	.40

[a] In each bend the piece of plate was bent from a vertical position to an angle of 90 degrees and back again to the vertical.

[b] Transverse divided by lengthwise bends.

NOTE.—Sample located midway between centers and edges of representative sheets.

APPENDIX XXIII.—MICROSCOPIC EXAMINATION OF TIN PLATE.

TABLE 90.—CHARACTER OF THE STEEL AS SHOWN BY MICROSCOPIC EXAMINATION FOR SLAG INCLUSIONS OF UNETCHED SECTIONS OF CANS FROM 1917 EXPERIMENT.

TIN PLATE THAT GAVE GOOD SERVICE WITHOUT FAILURE.

Experimental Steel.

R1XP	Clean.	CT1XP	Clean.
R1XP	Clean.	CT1XP	Clean.
R1AP	Clean.	CT1AP	Clean.
R1AP	Clean.	CT1AP	Clean.
CR1XP	Considerable slag.	T3XP	Large slag streak.
CR1XP	Clean.	T3XP	Clean.
CR1AP	Clean.	T3AP	Clean.
CR1AP	Clean.	T3AP	Some slag.
T1XP	Clean.	R5XP	Clean.
T1XP	Clean.	R5XP	Some slag.
T1AP	Clean.	R5AP	Large slag streak.
T1AP	Clean.	R5AP	Clean.

TIN PLATE THAT PERFORATED IN SERVICE.

Experimental Steel.

R2XNN	Clean.	R4AN	Clean.
R2XNN	Some slag.	R4XN	Little slag.
R2AN	Clean.	R4XNN	Clean.
R2XN	Some slag.	R4XNN	Clean.
CR2AN	Some slag.	R6AN	Clean.
CR2ANN	Clean.	R6ANN	Clean.
CR2XN	Little slag.	R6XN	Some slag.
CR2XNN	Some slag.	R6XNN	Clean.
CR3AN	Clean.	CT3AN	Clean.
CR3AN	Some slag.	CT3ANN	Clean.
CR3XN	Clean.	CT3XN	Clean.
CR3XNN	Clean.	CT3XNN	Clean.

Commercial Steel.

Open Hearth.		*Bessemer.*	
CH2XNN	Dirty; slag abundant.	B1XNN	Dirty; slag abundant.
H3AN	Considerable slag.	B1XN	Some slag.
H3ANN	Dirty.	CB1XN	Dirty; slag abundant.
CH3XNN	Clean.	CB1AN	Some slag.
H4XN	Clean.	B2XN	Clean.
H4XNN	Little slag.	B2AN	Dirty; slag abundant.
CH4ZNN	Little slag.	CB2AN	Dirty; slag abundant.
		CB3XN	Dirty; slag abundant.

TABLE 91.—CHARACTER OF STEEL AS SHOWN BY MICROSCOPIC EXAMINATION OF ETCHED SECTIONS OF CANS FROM 1917 EXPERIMENT.

TIN PLATE THAT GAVE GOOD SERVICE WITHOUT FAILURE.

Experimental Steel.

R1XP.....Large ferrite grains, pearlite segregated at edges; center carbon free.
R1XP.....Same.
R1AP.....Same.
R1AP.....Same with some massive cementite in center.
CR1XP.....Large ferrite grains, massive cementite throughout.
CR1XP.....Pearlite at edges, center carbon-free.
CR1AP.....Same.
CR1AP.....Same.
T1XP.....Pearlite at edges, massive cementite in center.
T1XP.....Same with less pearlite.
T1AP.....Same with little more pearlite.
T1AP.....Massive cementite throughout in small particles
CT1XP.....Pearlite at edges, massive cementite in center.
CT1XP.....Same with less pearlite.
CT1AP.....Same with more pearlite and distinct phosphorus markings.
CT1AP.....Same without phosphorus markings.
T3XP.....Pearlite at edges, center carbon-free.
T3XP.....Same.
T3AP.....Same.
T3AP.....Pearlite and massive cementite both scattered throughout.
R5XP.....Very large ferrite grains, massive cementite.
R5XP.....Pearlite and cementite near edges, center carbon-free.
R5AP.....Large ferrite grains, few cementite masses.
R5AP.....Pearlite and cementite near edges, center carbon-free.

TIN PLATE THAT PERFORATED IN SERVICE.

Experimental Steel.

R2XNN.....Large ferrite grains, pearlite segregated at edges, massive cementite in center.
R2XNN.....Same.
R2AN.....Same with only traces of massive cementite in center.
R2XN.....Same with some pearlite also in center.
CR2AN.....Same with distinct phosphorus markings.
CR2ANN.....Same.
CR2XN.....Same without pearlite in center.
CR2XNN.....Same.
CR3AN.....Very large ferrite grains, massive cementite throughout; distinct phosphorus markings.
CR3AN.....Same with massive cementite in smaller particles.
CR3XN.....Pearlite at edges; massive cementite in center, distinct phosphorus markings.
CR3XNN ....Same.
R4AN.....Large ferrite grains, massive cementite at edges in small masses, center carbon-free.
R4XN.....Large ferrite grains, massive cementite throughout .
R4XNN.....Same with finer cementite.
R4XNN.....Cementite segregated at edges in groups of small particles.
R6AN.....Large ferrite grains, massive cementite throughout in small particles.
R6ANN.....Same.
R6XN.....Same.
R6XNN.....Same with cementite in larger particles.
CT3AN.....Same.
CT3ANN.....Same with traces of pearlite at edges.
CT3XN.....Same with more pearlite.
CT3XNN.....Same with less pearlite.

Commercial Steel.

Open Hearth.

CH2XNN....Medium ferrite grains, massive cementite, phosphorus markings.
H3AN.....Small ferrite grains, granular cementite.
H3ANN.....Medium ferrite grains, nearly carbon-free except at extreme edges.
CH3XNN....Medium ferrite grains, cementite at edges, carbon-free center, phosphorus markings.
H4XN.....Large ferrite grains, massive cementite scattered throughout.
H4XNN.....Large ferrite grains, cementite and pearlite at edges, carbon-free center.
CH4ZNN.....Medium ferrite grains, massive cementite throughout, phosphorus markings.

Bessemer.

B1XNN.....Large ferrite grains, massive cementite, phosphorus markings.
B1XN.....Medium ferrite grains, granular cementite, phosphorus bands.
CB1XN.....Large ferrite grains, massive cementite especially near edges, phosporus markings.
CB1AN.....Large ferrite grains, cementite mostly massive, little granular, phosphorus markings.
B2XN.....Large ferrite grains, cementite and pearlite near edges, carbon-free center.
B2AN.....Large ferrite grains, cementite mostly massive, little granular, phosphorus markings.
CB2AN.....Medium ferrite grains, massive cementite, phosphorus markings.
CB3XN.....Same.

TABLE 92.—CHARACTER OF STEEL AS SHOWN BY MICROSCOPIC EXAMINATION OF SECTIONS CUT NEAR PERFORATIONS IN MISCELLANEOUS CANS FROM 1917 EXPERIMENT.

UNETCHED SECTIONS.

B1XP.....Little slag.
CB1XN.....Considerable slag in small particles.
AT4AN.....Little slag.
CB1XN.....Some slag near surface.
T7ANN.....Clean.
H2ANN.....Large amount of slag.
CR2ANN.....Slag scattered throughout; corroded spot near inclusions
CR2AN.....Little slag.
CR2AN.....Considerable slag; one particle at perforation.
CR2AN.....Little slag; one particle near perforation.
T6AN.....Large amount of slag.
T6XN.....Clean.
T7ANN.....Large amount of slag.
T7AP.....Some slag.
CR2AN.....Same.
AT4AN.....Same.

ETCHED SECTIONS.

B1XP.....Medium ferrite grains, small massive cementite throughout, phosphorus markings
CB1XN.....Medium ferrite grains, granular cementite, phosphorus banding.
AT4AN.....Medium ferrite grains, pearlite near edges, center carbon-free.
CB1XN.....Medium ferrite grains, massive cementite, phosphorus markings.
T7ANN.....Medium ferrite grains, pearlite near edges, center carbon-free
H2ANN.....Medium ferrite grains, granular cementite, phosphorus banding.
CR2ANN.....Large ferrite grains, pearlite near edges, some massive cementite in center, phosphorus markings
CR2AN.....Same.
CR2AN.....Same.
CR2AN.....Same.
T6AN.....Small ferrite grains, pearlite and massive cementite scattered throughout.
T6XN.....Large ferrite grains, pearlite near edges, massive cementite in center, phosphorus markings.
T7ANN.....Same except medium ferrite grains.
T7AP.....Large ferrite grains, massive cementite, some pearlite along edges, phosphorus markings.
CR2AN.....Large ferrite grains, pearlite along edges, massive cementite in center, phosphorus markings.
AT4AN.....Medium ferrite grains, pearlite near edges, center carbon-free.

TABLE 93.—CHARACTER OF STEEL AS SHOWN BY MICROSCOPIC EXAMINATION OF REPRESENTATIVE SAMPLES OF TIN PLATE, BEFORE AND AFTER ETCHING, 1919 EXPERIMENT.

Plate.	Amount of slag.	Sulphide inclusions.	Condition of carbide.	Ferrite grain size.	Phosphorus bands in ferrite.
R21	Small	Few	Fine	Large	Slight
CR21	do.	do.	do.	do.	do.
SR21	Medium	Very few	do.	do.	None
SCR21	do.	do.	Segregated	do.	do.
T21	Very small	do.	Fine	Medium	Distinct
CT21	Small	do.	do.	Large	None
ST21	Medium	do.	do.	do.	do.
SCT21	Large	do.	None	Small	do.
R22	Small	Many	Fine	Medium	Distinct
CR22	do.	Few	do.	Large	do.
SR22	Medium	Very few	do.	do.	None
SCR22	Small	do.	do.	Medium	do.
T22	Very small	Few	do.	Large	Distinct
CT22	do.	Very few	do.	do.	do.
ST22	Small	do.	do.	do.	None
SCT22	do.	do.	do.	do.	do.
R23	Very small	Many	Slightly segregated	do.	do.
CR23	Small	Few	Fine	do.	Distinct
SR23	Large	Very few	do.	Medium	do.
SCR23	do.	do.	do.	Large	do.
T23	Small	Few	do.	do.	None
CT23	do.	do.	do.	do.	Slight
ST23	Medium	Very few	do.	do.	do.
SCT23	do.	do.	do.	do.	do.
R24	Small	Medium	Slightly segregated	Medium	Distinct
CR24	Very small	Few	Fine	Large	do.
SR24	Large	do.	do.	do.	Slight
SCR24	Medium	Very few	do.	do.	Distinct
T24	do.	Few	do.	do.	do.
CT24	Small	Medium	do.	do.	do.
ST24	Medium	Very few	do.	do.	do.
SCT24	Small	do.	do.	do.	None

APPENDIX XXIV.—GELATINE TEST OF 1917 PLATE.

The gelatine test for this work was made in accordance with the procedure outlined in the following directions:

1. Clean the plates thoroughly with soft cotton saturated with petroleum ether.

2. Use a tinner's brake to turn up vertically about one-half inch of the edges of the plate and, after bending in the corners, make sure that the pans so formed lie perfectly flat.

3. Make up the gelatine solution so that each liter will contain:—

250 grams medium-grade gelatine which has been tested and found practically neutral in reaction and free from reducing agents. (If the solution made with this amount and poured at a temperature of 38° C. (100°F.) will not set in 10 to 15 minutes in a room at about 24° C. (75°F.), use a slightly greater quantity.)

15 cc. 10% solution of potassium ferricyanide.

1 cc. hydrochloric acid, C. P., sp. gr. 1.20.

25 cc. glycerine, C. P.

0.5. cc. chloroform.

4. In making up this mixture first soak the gelatine for about an hour in one-half the water and then add the remainder of the water (hot) to bring it to volume. In all operations carefully avoid any contamination of the solution with iron. As it may turn green on prolonged standing, the ferricyanide should not be added until the gelatine is about to be poured on the sheets.

5. Thoroughly mix all of the solution and bring it to a temperature between 38° and 41° C. (100° and 105° F.).

6. After placing, on a flat surface, each of the pans made from the plate to be tested, pour into them a uniform volume of the gelatine solution.

7. After pouring allow the plates to remain in place until the gelatine has set. This should take from about 10 to 15 minutes. Success has not been realized when using solutions where the gelatine sets in less than 7 or 8 minutes, since these result in media which are too stiff to permit of sufficient diffusion of the blue formed at the pin holes.

8. Allow all the plates to stand in a closed room until ready for grading. (Localized drafts cause the surfaces to dry out and thereby vary the conditions of the test.)

The most important point to be observed in making these tests is that, no matter how carefully the various solutions have been made up, tests made with different batches of gelatine solution must not be compared with each other. The test is only of value when sheets that have been flowed with the same gelatine solution, with all conditions constant, are compared at the same time.

TABLE 94.—RESULTS OF GELATINE TESTS, 1917 EXPERIMENT.

Lots.	Grade given by—							Average.
	A.	B.	C.	D.	E.	F.	G.	
R1X	2	2	2	2	3	2	1	2.0
R1A	1	2	4	2	3	1	2	2.1
CR1X	2	2	2	2	3	3	1	2.1
CR1A	2	3	3	4	4	4	2	3.1
T1X	2	1	2	2	3	2	2	2.0
T1A	1	1	1	2	3	1	1	1.4
CT1X	1	1	2	2	2	1	1	1.4
CT1A	2	2	3	1	3	2	2	2.1
R2X	2	3	4	3	4	2	2	2.9
R2A	3	3	6	3	5	3	3	3.7
CR2X	4	4	5	3	5	3	3	3.9
CR2A	6	7	7	7	7	6	5	6.4
T2X	5	5	5	4	5	4	3	4.4
T2A	3	3	2	2	3	3	2	2.6
CT2X	8	8	8	7	6	9	6	7.4
CT2A	8	8	8	8	8	8	6	7.7
R3X	3	3	3	1	4	2	2	2.6
R3A	4	3	3	3	4	3	2	3.1
CR3X	4	4	3	3	4	3	2	3.3
CR3A	8	7	7	6	6	6	[a] 3	6.7
T3X	5	4	4	4	5	3	2	3.9
T3A	7	6	5	7	6	4	3	5.4
CT3X	4	5	2	4	4	2	3	3.4
CT3A	8	8	9	8	8	8	8	8.1
R4X	4	5	3	4	6	4	2	4.0
R4A	8	6	7	8	6	6	7	6.9
T4X	3	3	4	3	2	2	1	2.6
T4A	8	8	9	8	9	9	9	8.6
R5X	6	6	7	5	6	6	5	5.9
R5A	7	7	8	6	6	7	6	6.7
T5X	6	5	5	5	4	3	5	4.7
T5A	7	7	8	8	7	6	5	6.9
R6X	5	3	5	2	5	5	3	4.0
R6A	6	4	6	4	5	7	3	5.0
T6X	3	2	3	3	3	3	2	2.7
T6A	9	8	7	8	8	8	9	8.1
R7X	3	3	4	3	4	4	2	3.3
R7A	6	8	7	5	6	8	[a] 4	6.7
T7X	5	7	4	4	6	5	4	5.0
T7A	9	8	8	8	8	8	7	8.0
H1X	8	7	7	6	8	8	8	7.4
H1A	6	5	5	6	5	4	5	5.1
CH1X	5	4	5	3	4	6	5	4.6
CH1A	3	1	2	1	2	3	2	2.0
H2X	10	8	10	9	8	9	7	8.7
H2A	5	7	5	6	5	5	6	5.6
CH2X	4	4	6	3	4	7	4	4.6
CH2A	10	9	10	10	9	9	10	9.6
H3X	6	5	7	5	6	7	4	5.7
H3A	4	2	3	3	2	3	3	2.9
H4X	6	5	5	4	5	6	6	5.3
CH4Z	10	7	8	9	7	9	7	8.1
B1X	6	6	7	5	6	8	6	6.3
B1A	8	6	7	8	7	5	6	6.7
CB1X	5	4	6	5	6	6	5	5.3
CB1A	10	7	7	9	6	7	7	7.6
B2X	6	6	7	5	5	8	6	6.1
B2A	5	3	3	4	5	6	5	4.4
CB2X	6	6	7	5	5	7	6	6.0
CB2A	10	7	8	7	7	8	9	8.0
B3X	7	5	4	3	5	7	4	5.0
CB3X	6	4	6	5	4	5	5	5.0
B4X	8	4	7	6	4	8	6	6.1
ER3X	6	6	5	4	6	7	8	6.0
ET4X	5	3	3	4	5	7	4	4.4
AR3X	6	4	4	2	4	6	3	4.1
AT4X	3	4	3	4	4	5	3	3.7
AR3A	8	7	6	6	8	8	8	7.3
AT4A	2	2	3	1	2	2	2	2.0
SR3A	7	8	8	6	8	9	[a] 4	7.7
ST4A	2	1	4	2	[a] 6	3	2	2.3

[a] Not included in averages.

APPENDIX XXV—RUSTING TESTS OF 1917 AND 1919 TIN PLATE.

Tables 95, 96 and 97 give the gradings of plate for rust at the last examination of each of the three lots of plate exposed on a fence in Baltimore. At each grading the worst sheet that was at all comparable with the slightly rusted ones was graded 10. The lower grades show the relative amounts of rust, with 0 given to a sheet practically free from rust. Some sheets were almost covered with rust and could not well be compared with the slightly rusted sheets. These were graded XX. In computing averages, XX was taken as 20, though it probably represented much more than twice the quantity of rust on a sheet marked 10.

TABLE 95.—RUSTING TEST; AVERAGE FINAL GRADINGS MAY 28, 1918, OF TIN PLATE EXPOSED DECEMBER 2, 1917.

Plate.	Grading.		Plate.	Grading.		Plate.	Grading.	
	Sheet 1.	Sheet 2.		Sheet 1.	Sheet 2.		Sheet 1.	Sheet 2.
R1X	1.2	0.3	R4X	1.3	1.2	H3X	3.5	3.5
R1A	.9	.3	R4A	.3	.5	H3A	.2	.1
CR1X	.6	.8	T4X	.9	1.5	H4X	5.0	5.7
CR1A	.3	.4	T4A	.8	2.3	CH4Z	.4	.5
T1X	3.3	3.0	R5X	1.5	1.7	B1X	3.3	3.7
T1A	1.8	3.0	R5A	1.3	.3	B2X	6.2	6.2
CT1X	.8	1.5	T5X	.4	1.5	B1A	.9	.9
CT1A	.6	.4	T5A	.4	.3	B2A	4.2	3.8
R2X	.6	1.8	R6X	1.5	1.0	CB1X	4.7	5.3
R2A	.5	.4	R6A	1.8	1.0	CB1A	.6	1.2
CR2X	.4	.4	T6X	1.1	2.2	ER3X	2.8	4.8
CR2A	.2	.5	T6A	.5	.7	ET4X	4.0	3.0
T2X	2.3	1.7	R7X	2.0	2.8	CB2A	.2	.8
T2A	.2	.9	R7A	1.4	.3	B3X	4.8	7.2
CT2X	1.2	1.7	T7X	1.8	3.3	CB3X	8.0	8.2
CT2A	.2	.2	T7A	1.8	.3	B4X	4.0	5.0
R3X	1.7	1.5	H1X	3.5	4.2	CB2X	9.8	10.0
R3A	.3	.3	H1A	1.5	2.7	AR3X	1.0	.7
CR3X	.7	1.3	CH1X	4.2	5.3	AT4X	1.7	2.0
CR3A	1.7	1.5	CH1A	.4	.5	AR3A	.3	.3
T3X	2.0	1.2	H2X	2.5	2.5	AT4A	.4	.5
T3A	.4	.5	H2A	1.6	1.7	SR3A	.2	.2
CT3X	1.5	1.8	CH2X	4.5	4.8	ST4A	.1	.0
CT3A	.4	.4	CH2A	3.7	2.7	T6A [a]	.....	.....
						T7A [a]	.....	.3
						R4A [a]	.....	.1

[a] Sheets washed with benzol.

TABLE 96.—RUSTING TEST; AVERAGE FINAL GRADINGS MAY 28, 1918, OF TIN PLATE EXPOSED MARCH 22, 1918.

Plate.	Grading.	Plate.	Grading.	Plate.	Grading.
SW	6.0	CB2A	1.2	H3A	.0
SP	9.2	H2X	11.5	CH2X	9.2
SO	8.2	H2A	1.5	AT4X	3.0
SK	16.0	CH4Z	.0	ST4A	.1
SR	13.6	B2A	2.3	ET4X	1.5
SY	8.2	CH1A	2.8	H2A	2.0
SI	18.0	CB1A	2.8	H1A	7.2
ST	7.6	H1X	8.8	SR3A	.1
SX	9.0	CB2X	18.8	R5A	.2
SU	9.0	B4X	15.0	R7X	3.0
SZ	6.8	CB1X	6.7	B1A	5.0
SN	9.0	B3X	9.5	AT4A	3.5
SM	XX	CH2A	5.2	R7A	6.6
SS	4.3	B2X	9.0	AR3A	.9
R5X	.4	R4X	.4	T4A	.7
T6X	.2	B1X	3.2	ER3X	2.7
T5A	.1	H3X	9.8	R6A	.3
CH1X	16.7	H4X	9.8	T4X	2.3
T7X	3.8	AR3X	1.3	.....	.....

NOTE.—The first fourteen plates in the above table were commercial plate used for comparison. The designations have no relation to tne composition of the plate.

TABLE 97.—RUSTING TEST; AVERAGE FINAL GRADINGS OCTOBER 24, 1918, OF TIN PLATE EXPOSED JULY 26, 1918.

Plate.	Grading.		Plate.	Grading.		Plate.	Grading.	
	Sheet 1.	Sheet 2.		Sheet 1.	Sheet 2.		Sheet 1.	Sheet 2.
R1X	2	.....	CT3A	2	Tr	CH2A	8	7
R1A	1	1	R4X	1	2	H3A	1	Tr
CR1X	6	2	R4A	1	1	CH3X	10	9
CR1A	1	Tr	T4X	2	3	H4X	XX	XX
T1X	3	3	T4A	Tr	1	CH4Z	1	Tr
T1A	1	1	R5X	2	2	B1A	2	2
CT1X	3	3	R5A	1	Tr	CB1X	10	10
CT1A	1	Tr	T5X	4	2	CB1A	2	2
R2X	3	2	T5A	2	0	B2X	XX	10
R2A	1	1	R6X	6	3	B2A	6	3
CR2X	3	2	R6A	1	1	CB2X	XX	XX
CR2A	2	1	T6X	4	2	CB2A	1	Tr
T2X	3	3	T6A	1	4	B3X	XX	XX
T2A	2	Tr	R7X	6.5	.....	CB3X	10	9
CT2X	3	3	R7A	2	Tr	B4X	10	8
CT2A	Tr	Tr	T7X	7	2	ER3X	4	3
R3X	5	3	T7A	1	2	ET4X	4	2
R3A	2	1	H1X	XX	XX	AR3X	4	1
CR3X	8	4	H1A	6	7	AT4X	2	2
CR3A	1	Tr	CH1X	XX	XX	AR3A	2	3
T3X	2	3	CH1A	Tr	1	AT4A	2	3
T3A	1	1	H2X	10	XX	SR3A	0	0
CT3X	2	3	H2A	2	1	ST4A	1	1

NOTE.—Tr = trace.

The results of the individual gradings are brought together in different combinations in tables 98, 99 and 100 to bring out the relations between different characteristics of the plate and the amount of rusting. Since the gradings of the lots exposed at different times were not comparable the average gradings have all been expressed with reference to the first kind of steel or plate given in each table.

Table 98 shows relative gradings on the basis of the types of steel. The average for R at each exposure is taken as the unit. This average was made from the grades of all sheets of regular plate without copper, including both coke and charcoal coatings. The average for T is from grades of all titanium-treated plate without copper, including both coke and charcoal. H and B represent corresponding averages for the open-hearth and Bessemer plate, respectively.

TABLE 98.—RELATIVE RUSTING OF 1917 PLATE WITH REFERENCE TO TYPE OF STEEL BASE.

Plate.	Grading of plate exposed—		
	Dec. 2, 1917.	Mar. 22, 1918.	July 26, 1918.
R	1.0	1.0	1.0
T	1.4	.8	1.1
H	2.6	3.4	5.4
B	4.0	4.0	5.1

The table shows that the regular and titanium plates were about the same. The Bessemer was measurably less resistant than the open-hearth in two instances out of three, but the commercial plate was decidedly poorer than that made specially for the experiment.

To show the effect of weight of coating the grades were averaged for all the regular and titanium coke-coated plates, both copper-bearing and non-copper. This average (RX + TX) was taken as the unit for comparison for each lot

exposed. RA + TA include all the charcoal plate, regular and titanium, both with and without copper. HX + BX and HA + BA are from the corresponding averages for the commercial plate.

TABLE 99.—RELATIVE RUSTING OF 1917 PLATE WITH REFERENCE TO WEIGHT OF COATING.

Plate.	Grading of plate exposed —		
	Dec. 2, 1917.	Mar. 22, 1918.	July 26, 1918.
RX + TX.....	1.0	1.0	1.0
RA + TA.....	.4	.5	.4
HX + BX.....	3.2	4.5	4.9
HA + BA.....	.9	1.3	.8

This tabulation brings out the superiority of the heavier coated plate. The charcoal plate made for the experiment had only about one-half more tin coating than the coke, and rusted much less as is shown in Table 99. The difference in weights of coating of coke and charcoal was greater for the commercial plate and the difference in rusting was correspondingly greater.

The next table gives the gradings of the 1917 plate arranged with reference to copper in the steel. Since copper was added to only three heats of steel for the experimental plate, the grades for sheets from the other heats are omitted. In table, R + T includes sheets from heats R 1, R 2, R 3 and T 1, T 2 and T 3. These sheets contained no added copper and included both coke and charcoal coatings. CR+CT includes sheets from the corresponding copper-bearing steels. In the commercial plate, all the non-copper are included in H + B and the copper in CH + CB. Average gradings are given in relation to the averages for R + T taken as 1 for each series.

TABLE 100.—RELATIVE RUSTING OF 1917 PLATE WITH REFERENCE TO COPPER ADDITION TO STEEL.

Plate.	Grading of plate exposed—		
	Dec. 2, 1917.	Mar. 22, 1918.	July 26, 1918.
R + T.....	1.0	1.0	1.0
CR + CT.....	.6	.....	1.0
H + B.....	2.7	4.1	5.0
CH + CB.....	3.3	4.9	3.3

There is no large effect that can be attributed to the copper either with the experimental plate or the commercial plate.

Average grades have been calculated to show the effect on rusting of different variables in the 1919 experiment. These averages have been calculated to a basis of 1 for the regular plate.

TABLE 101.—RELATIVE RUSTING OF 1919 PLATE FROM DIFFERENT KINDS OF STEEL.

Plate.	Grading.	Plate.	Grading.
R.....	1.0	T.....	1.0
CR.....	1.1	CT.....	.6
SR.....	1.0	ST.....	.8
SCR.....	.8	SCT.....	.9

APPENDIX XXVI.—PACKING PROCEDURE.

1917 Experiment.

CIDER.

Cider was canned at a New York plant on November 12, 1917. The apples used were of different varieties obtained in the neighborhood. They were ground and the cider was pressed out in the usual manner until a sufficient amount was obtained to fill all the cans desired. The cider was mixed in a tank by blowing air through it. The cans were filled to within about 3/8 of an inch of the top, the cider being cold. The cans were closed and processed fifteen minutes in an open bath. They were then cooled in a tank and packed away in cases. One complete set of cans was filled with cider—two cases of plain and one case of enameled and renamelel for each lot of tin plate.

Every effort was made to secure uniformity in the product packed. The lots of cans were filled in such order that they would not be affected by any unavoidable lack of uniformity in the product. The same procedure was followed with other products.

APPLES.

The apples were packed November 13, 1917, at a New York plant, but were obtained from a Pennsylvania locality, apples from which had caused the greatest percentage of perforations in a previous experiment.

On account of the small supply of apples only plain cans were filled, one case of each lot. The apples were sliced in a slicing machine and mixed thoroughly by shoveling over in a pile on the floor. They were packed into the cans by hand. Each can was weighed and the amount of product adjusted so as to give a weight of 13 ounces in each can. The cans were brined with plain water at a temperature of about 160° F. They were closed in the double seamer and processed for ten minutes in an open bath. They were cooled in a tank of cold water and packed in cases.

STRAWBERRIES.

Strawberries were packed June 21, 1918, at a New York canning factory, the berries being purchased in a city market. The greater part were of the Wilson variety and were fairly uniformly ripe but not overripe. They were hulled by hand and washed in the regular manner. They were filled by hand into the cans and each can was adjusted to contain 11 ounces of berries, which is a slack fill. The cans were filled with about 10 ounces of water at a temperature of about 200° F. and were conveyed from the syruper to the closing machine without any further heating. After closing them they were processed twenty minutes at 212° F. and cooled.

BLUEBERRIES.

Blueberries were packed in Maine on August 15, 1918. The berries were brought to the plant in small boxes, which were filled in the fields from the rakes used in picking the fruit. They were first dumped into a fanning mill, which took out sticks, leaves, etc. From this machine, they were dumped on to the picking

table and gone over by hand. The berries were then fed into a Hemingway cooker, where they were heated with live steam at a temperature of 180° to 190° F. The berries dropped from the cooker into a large receiving tank, from which they were filled into the cans by hand. No exhaust or process was used. The cans were washed with cold water when leaving the double seamer and then run to the warehouse and packed into cases, which were staggered to prevent stack burning.

CORN.

Corn of the Crosby variety was packed in Maine, September 13, 1918. It was of very good quality, the ears being well matured and uniformly filled out. The ears were machine husked, and carried by an automatic belt to the cutting machine. The usual Maine procedure for the packing of corn was followed. The temperature of the cooker varied from 180° to 190° F. during the run. The cans were uniformly filled so that while the corn was hot the cover was practically in contact with the product when sealed. The cans were run in the regular order, that is, the order in which they were manufactured. As the cans were stacked in the crates a mark was placed on the top of the can so that the end which stood up could be identified.

The process given was 65 minutes at 250° F., after which the cans were cooled. After cooling they were boxed at a temperature which would approximate 130° to 140° F. on the average.

PEAS.

The experimental pack of peas did not include all heats of steel. Two regular steels and two titanium steels were employed in both coke and charcoal coating, thus making eight lots in all. Only one dozen cans of each lot were packed. The purpose was to study the formation of black. Peas were packed in New York state and were all No. 3 screened. Peas were filled into the can, brine added at near the boiling point, the cans sealed and processed 35 minutes at 240° F. The product was immediately shipped to Washington.

CATSUP.

The catsup used for this experiment was packed September, 1918, in New York state and was a rather heavy, fairly acid product. For preparation of 300 gallons of the finished product approximately 800 gallons of ordinary tomato pulp were used. The acidity of the finished product averaged about 1.3 per cent, and sugar was added in the proportion of about 1.25 pounds per gallon of finished material. Usual spices were added, and the product was finished after the final boiling in order to remove the residue of onions and other material used for condimental purposes. The catsup was filled into the cans hot and was given a process of 20 minutes at 212° F.

1919 Experiment.

BLACK RASPBERRIES.

Black raspberries were packed in New York state July 17, 1919. The berries were in very good condition, were firm, ripe and uniform. In order to have more air than is customary in the cans they were slack filled and the water was added in such an amount that the proportion of berries and water was about normal. Nine ounces of berries were weighed into each can and boiling water added. The excess of water was forced out of each can by the use of a plunger of wood,

about the diameter of the can, which reached ½ inch into the can. The cans were not exhausted but were carried on the conveyor of the exhaust box, taking about two minutes from the syruper to the closing machine. They were processed 15 minutes in an open bath and colled in water.

RED RASPBERRIES.

Red raspberries of the Cuthbert variety were packed in New York state July 18, 1919. The berries were not very uniform in size and degree of ripeness. Nine ounces of berries were weighed into each can. The cans were filled with water and the excess removed by the use of the same plunger that was used in filling the black raspberries. This left a head space of ½ inch. The water for the plain cans was added at a temperature of 170° F. The water for the enameled cans was at a temperature of 185° F. The cans were sealed without exhaust and were processed 15 minutes in an open bath and cooled in water.

BLUEBERRIES.

Blueberries were packed in Maine on August 12, 1919. The same packing procedure was followed as in the 1917 experiment.

PEACHES.

Peaches were packed September 22, 1919, in Michigan. Most of the peaches were of the Chili variety, and were overripe. The peaches were pitted but not peeled. About 14 ounces were filled into each can by hand. The plain cans were all filled before any were closed. Immediately after completion of filling they were put through the line. The cans were filled with boiling water and were exhausted for 3 minutes in a steam and water exhaust box, the cans standing to about two-thirds of their height in the boiling water. After exhausting, the excess of water was forced out by a wooden plunger applied by hand to each can. The plunger reached ½ inch into the can and covered practically its entire diameter. The cans were closed and processed 18 minutes at 218° F. They were cooled in a tank of water and cased.

APPLES.

The apples were packed in New York state in October, 1919, in the vicinity in which they were picked, and they were the usual varieties canned at that plant.

The apples were peeled and cored by machine and were then sliced in a slicing machine and mixed by shovelling over in a pile on the floor. The cans were filled by hand, 13 ounces of apples being weighed into each can. The cans were then brined with plain water at a temperature of about 150° F., were closed in the usual manner and processed 8 minutes in an open bath. They were then cooled in water and packed in cases.

CIDER.

The cider was canned in New York state in October, 1919. The apples were not of selected varieties, but were the ordinary cider stock of that neighborhood. They were ground, and the cider was pressed out in the usual manner and stored in a tank, where it was mixed by blowing air through it. The cider was filled cold to within about ⅜ inch of the top and the cans were closed and processed 15 minutes in an open bath. They were then cooled in water and packed in cases.

APPENDIX XXVII.—METHOD OF RECORDING FAILURES.

In figure 126 the letters at top of column indicate code mark of cans in that column. Figures at left side of diagram indicate shelf numbers. Figures at left of each column indicate springers, the year being indicated by the letter and the month by numeral. Perforations are indicated at right of each column, the numeral indicating the month and the form of inclosure indicating the year; "b" indicates perforation in the body of the can and "ss" in the side seam. All other perforations were in the end of the can.

	RIN	CRIN	SRIN	SCRIN	R2N	CR2N	SR2N	SCR2N
1		[2]		[2]	X7	X8 (10)	X4 (7)	X4 (12)
2			X11 (12)	X11		X8 (9)b	(4)	X4 (10)
3				(11)	Y3	Y1 [3]	X4 (7)	[11]
4		(6)		y2		X11	X4 (5)	X4 [12]
5		(12)	(11)	[2]	Y2	(7)	X4 (5)	X4 (11)
6			(12)			(8)b	X4 (5)	X6
7				X10 [2]	[3]	(8)b	X4 (5)	X6 (12)ss
8		[3]		Y3	[11]	X4 (6)	X4 (11)	X8 (12)ss
9		(11)	Y2		X9 [11]	(11)	X4 (9)	X4 [11]ss
10		(12)			X9 (11)	[11]	X4 (5)	X7 [3]
11	(12)		Y1			(8)	X4 (12)	X6 (7)
12			X9 [11]	Y2	(11)	X10	X4 (5)	X5 (12)ss
13	(6)		Y3			(6)b	X4 (6)	X4 (7)ss
14		(9)b	X9 (10)			(11)	X4 (5)	(8)b
15		(10)	X9			(12)	X4 (5)	X6 (8)b
16		X8			[11]	(10)	X4 (5)	X6 [3]
17		[3]	X9 (12)	[3]	X8 (11)	X12	X4 (6)	X5 [3]
18		[2]	Y2	(11)	X8 [11]	(8)b	X4 (7)	X7
19		(11)	[3]		[11]		X4 (7)	X6
20	[3]		Y3		X7 (8)	(12)b	X4 (7)	X5 [11]
21			Y1			Y1	X4 (6)	X9 [11]b
22					X8 (10)	(9)	X4 (9)	(8)ss
23		[11]			Y1		X4 (5)	X4 (8)ss
24				Y1		(11)	X4 (7)	X4 (8)b

FIG. 126.—Illustration of warehouse record, and method of recording failures.

APPENDIX XXVIII.—RELATION OF SPRINGERS TO PERFORATIONS.

TABLE 102.—PERCENTAGE OF SPRINGERS, PERFORATIONS, AND TOTAL FAILURES, AT SPECIFIED INSPECTION DATES, OF CIDER, PEACHES, BLUEBERRIES AND BLACK RASPBERRIES, PACKED IN ENAMELED CANS: AVERAGE OF ALL HEATS, REGULAR 1919 EXPERIMENTAL PLATE.

Inspection date.	Cider.				Peaches.				Blueberries.				Black raspberries			
	Storage period.	Springers.	Perforations.	Total failures.	Storage period.	Springers.	Perforations	Total failures.	Storage period.	Springers.	Perforations.	Total failures.	Storage period.	Springers.	Perforations.	Total failures.
	Months.	*P. ct.*	*P. ct.*	*P. ct.*	*Months.*	*P. ct.*	*P. ct.*	*P. ct.*	*Months.*	*P. ct.*	*P. ct.*	*P. ct.*	*Months.*	*P. ct.*	*P. ct.*	*P. ct.*
Feb. 15, 1920.....	3.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0
April 1, 1920.....	4.5	0.8	7.1	7.9	6.5	12.6	3.1	15.7	7.5	1.1	3.6	4.7	8.5	.0	.0	.0
May 1, 1920.....	5.5	1.0	23.1	24.1	7.5	11.0	15.2	26.2	8.5	1.1	5.2	6.3	9.5	.0	.0	.0
June 1, 1920.....	6.5	1.0	54.1	55.1	8.5	6.8	27.2	34.0	9.5	.6	16.1	16.7	10.5	.0	.0	.0
July 1, 1920.....	7.5	2.6	67.8	70.4	9.5	5.2	37.7	42.9	10.5	4.2	20.3	24.5	11.5	1.0	1.6	2.6
Aug. 1, 1920.....	8.5	1.6	91.0	91.6	10.5	3.6	50.3	53.9	11.5	4.2	32.8	37.0	12.5	.5	22.2	22.7
Sept. 1, 1920.....	9.5	.7	97.5	98.2	11.5	1.1	58.1	59.2	12.5	4.1	42.2	46.3	13.5	.0	32.3	32.3
Oct. 1, 1920.....	10.5	.0	99.7	99.7	12.5	3.1	59.2	62.3	13.5	3.6	50.0	53.6	14.5	.0	39.1	39.1
Nov. 1, 1920.....	11.5	.....	100.0	100.0	13.5	1.0	65.0	66.0	14.5	1.6	57.3	58.9	15.5	.5	43.4	43.9
Dec. 1, 1920.....	.....	.....	.....	.....	14.5	1.1	66.0	67.1	15.5	2.1	59.4	61.5	16.5	.0	47.1	47.1
Jan. 1, 1921.....	.....	.....	.....	.....	15.5	1.5	67.1	68.6	16.5	1.5	64.1	65.6	17.5	1.0	59.3	60.3
Feb. 1, 1921.....	.....	.....	.....	.....	16.5	1.6	68.6	70.2	17.5	1.6	67.2	68.8	18.5	.5	60.3	60.8
Mar. 1, 1921.....	.....	.....	.....	.....	17.5	2.2	69.6	71.8	18.5	2.5	68.8	71.3	19.5	1.0	65.1	66.1

TABLE 103.—PERCENTAGE OF SPRINGERS, PERFORATIONS, AND TOTAL FAILURES, AT SPECIFIED INSPECTION DATES, OF CIDER, PEACHES, BLUEBERRIES, AND BLACK RASPBERRIES, PACKED IN ENAMELED CANS: AVERAGE OF ALL TYPES OF 1919 EXPERIMENTAL PLATE.

Inspection date	Cider.				Peaches.				Blueberries.				Black raspberries.			
	Storage period.	Springers.	Perforations.	Total failures.	Storage period.	Springers.	Perforations.	Total failures.	Storage period.	Springers.	Perforations.	Total failures.	Storage period.	Springers.	Perforations.	Total failures.
	Months.	*P. ct.*	*P. ct.*	*P. ct.*	*Months.*	*P. ct.*	*P. ct.*	*P. ct.*	*Months.*	*P. ct.*	*P. ct.*	*P. ct.*	*Months.*	*P. ct*	*P. ct.*	*P. ct.*
Feb. 15, 1920	3.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0
Apr. 1, 1920	4.5	.3	2.1	2.4	6.5	3.7	.8	4.5	7.5	.8	2.6	3.4	8.5	.0	.4	.4
May 1, 1920	5.5	.8	10.1	10.9	7.5	3.4	4.0	7.4	8.5	.8	3.1	3.9	9.5	.0	.5	.5
June 1, 1920	6.5	3.5	25.7	29.2	8.5	3.1	7.9	11.0	9.5	.5	7.4	7.9	10.5	.0	.5	.5
July 1, 1920	7.5	3.4	41.6	45.0	9.5	3.7	11.9	15.6	10.5	1.4	9.9	11.3	11.5	.2	2.0	2.2
Aug. 1, 1920	8.5	2.1	62.2	64.3	10.5	3.1	18.2	21.3	11.5	1.9	20.6	22.5	12.5	.2	19.2	19.4
Sept. 1, 1902	9.5	2.2	71.6	73.8	11.5	2.0	23.1	25.1	12.5	2.2	34.9	37.1	13.5	.1	28.3	28.4
Oct. 1, 1920	10.5	1.7	80.3	82.0	12.5	2.1	27.6	29.7	13.5	1.8	43.0	44.8	14.5	.1	36.9	37.0
Nov. 1, 1920	11.5	1.4	84.6	86.0	13.5	1.8	30.2	32.0	14.5	1.4	46.3	47.7	15.5	.1	43.0	43.1
Dec. 1, 1920	12.5	1.4	87.7	89.1	14.5	2.4	31.8	34.2	15.5	1.6	50.0	51.6	16.5	.1	46.9	47.0
Jan. 1. 1921	13.5	.7	90.5	91.2	15.5	2.5	34.0	36.5	16.5	1.5	53.2	54.7	17.5	.4	54.3	54.7
Feb. 1, 1921	14.5	.7	92.2	92.9	16.5	2.8	35.9	38.7	17.5	1.7	57.0	58.7	18.5	.4	56.4	56.8
Mar. 1, 1921	15.5	.6	93.9	94.5	17.5	2.6	38.0	40.6	18.5	1.8	59.0	60.8	19.5	.4	62.3	62.3

TABLE 104.—PERCENTAGE OF SPRINGERS, PERFORATIONS, AND TOTAL FAILURES, AT SPECIFIED INSPECTION DATES: AVERAGE OF CIDER, PEACHES, BLUEBERRIES, AND BLACK RASPBERRIES, PACKED IN ENAMELED CANS, ALL TYPES OF 1919 EXPERIMENTAL PLATE.

	Feb. 15, 1920.	Apr. 1, 1920.	May 1, 1920.	June 1, 1920.	July 1, 1920.	Aug. 1, 1920.	Sept. 1, 1920.	Oct. 1, 1920.	Nov. 1, 1920.	Dec. 1, 1920.	Jan. 1, 1921.	Feb. 1, 1921.	Mar. 1, 1921.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Springers	0.0	1.0	1.1	2.1	2.6	1.8	1.7	1.5	1.2	1.2	1.1	1.1	1.2
Perforations	.0	1.6	5.6	13.4	21.2	36.4	45.8	53.5	57.6	60.8	64.4	66.6	69 3
Total failures	.0	2.6	6.7	15.5	23.8	38.2	47.5	55.0	58.8	62.0	65.5	67.7	70.5

APPENDIX XXIX.—FAILURES AS AFFECTED BY USE OF TITANIUM.

TABLE 105.—PERCENTAGE OF FAILURES, DURING SPECIFIED PERIODS, IN CANS OF REGULAR AND OF TITANIUM-TREATED PLATE, 1917 EXPERIMENT, AVERAGE OF ALL HEATS: APPLES AND CIDER.

Code mark.	Number of cans.	Percentage of failures between date of packing, Nov. 13, 1917, and—													
		June 1, 1918 (6.5 mos.).	Aug. 1, 1918 (8.5 mos.).	Sept. 1, 1918 (9.5 mos.).	Oct. 1, 1918 (10.5 mos.).	Nov. 1, 1918 (11.5 mos.)	Dec. 1, 1918 (12.5 mos.).	Jan. 1, 1919 (13.5 mos.).	Feb. 1, 1919 (14.5 mos.).	Mar. 1, 1919 (15.5 mos.).	Apr. 1, 1919 (16.5 mos.).	May 1, 1919 (17.5 mos.).	June 1, 1919 (18.5 mos.).	July 1, 1919 (19.5 mos.).	Aug. 1, 1919 (20.5 mos.).
Apples.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
RXP	168	.....	1.2	5.4	6.5	10.1	14.9	16.1	17.3	19.6	30.3	33.3	35.1	36.9	37.5
TXP	168	0.6	1.2	2.4	2.4	2.4	2.4	3.0	3.6	5.4	13.1	14.9	16.7	17.3	20.8
RAP	167	.....	1.8	2.4	3.0	4.2	8.4	10.2	10.8	13.4	22.4	27.5	28.7	30.5	32.2
TAP	168	.....	.....	.....	.....	.....	1.2	1.2	1.2	1.2	7.1	7.7	10.1	10.1	13.7
Cider.															
RXP	336	.....	.9	1.2	1.5	1.5	3.6	5.1	5.4	7.1	17.3	20.2	22.3	26.5	32.7
TXP	336	.....	.....	.....	.....	.....	.....	.6	.6	.9	5.1	6.8	7.1	7.1	9.5
RAP	335	.....	.....	0.3	1.2	2.4	6.3	6.9	8.4	11.4	16.4	18.2	18.5	20.6	23.9
TAP	336	.....	.....	.....	.....	.....	.....	.6	.6	.6	4.5	4.8	4.8	7.4	8.6
RXN	340	9.7	24.4	38.2	43.5	51.7	66.5	69.1	72.9	79.7	83.3	85.9	87.3	89.7	92.9
TXN	335	3.0	11.9	21.2	26.2	34.0	44.8	48.6	51.9	60.3	68.3	74.6	79.4	83.9	88.9
RAN	335	3.3	10.5	17.6	23.9	29.8	40.6	44.2	50.1	58.8	68.1	71.6	74.1	76.7	85.3
TAN	334	.6	3.2	7.2	9.3	11.7	19.2	23.9	26.1	34.8	45.2	55.7	59.3	63.7	71.0

TABLE 106.—PERCENTAGE OF FAILURES, DURING SPECIFIED PERIODS, IN CANS OF REGULAR AND OF TITANIUM-TREATED PLATE, 1917 EXPERIMENT, AVERAGE OF ALL HEATS: BLUEBERRIES.

Code mark.	Number of cans.	Percentage of failures between date of packing, Aug. 15, 1918, and—														
		Dec. 1, 1918 (3.5 mos.).	Jan. 1, 1919 (4.5 mos.).	Feb. 1, 1919 (5.5 mos.).	Mar. 1, 1919 (6.5 mos.).	Apr. 1, 1919 (7.5 mos.).	May 1, 1919 (8.5 mos.).	June 1, 1919 (9.5 mos.).	July 1, 1919 (10.5 mos.).	Aug. 1, 1919 (11.5 mos.).	Sept. 1, 1919 (12.5 mos.).	Oct. 1, 1919 (13.5 mos.).	Nov. 1, 1919 (14.5 mos.).	Dec. 1, 1919 (15.5 mos.).	Jan. 1, 1920 (16.5 mos.).	Feb. 15, 1920 (18.0 mos.).	Apr. 1, 1920 (19.5 mos.).
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
RXP	168	.....	0.6	0.6	0.6	0.6	0.6	1.2	1.2	6.6	8.9	15.5	22.0	29.8	33.9	39.3	45.8
TXP	167	.....	.....	.6	.6	.6	.6	1.2	1.8	3.6	3.6	7.2	9.6	13.8	20.9	28.8	41.3
RAP	166	.....	.....	.....	.....	.....	.....	.6	.6	6.6	8.4	13.3	18.1	23.5	31.3	37.9	51.8
TAP	168	.....	.....	.....	.....	.....	.....	.....	.....	.6	2.4	5.4	8.9	13.2	20.8	28.0	41.7
RXN	329	.....	7.9	20.7	55.4	69.9	75.4	79.3	83.9	91.7	94.8	95.7	96.3	97.8	99.1	99.5	99.5
TXN	333	.....	3.9	10.2	48.4	56.1	61.9	70.3	77.2	85.6	89.5	92.1	95.1	95.5	98.4	99.1	99.1
RAN	333	0.3	4.2	10.2	29.7	37.5	46.6	55.5	64.2	71.2	77.5	81.6	87.0	90.1	91.3	96.7	98.0
TAN	333	.3	2.2	5.2	18.8	24.0	30.1	40.1	50.2	65.5	72.6	75.3	80.8	85.5	89.2	92.9	95.0

TABLE 107.—PERCENTAGE OF FAILURES, DURING SPECIFIED PERIODS, IN CANS OF REGULAR AND OF TITANIUM-TREATED PLATE, 1917 EXPERIMENT, AVERAGE OF ALL HEATS: STRAWBERRIES.

Code mark.	Number of cans.	Percentage of failures between date of packing, June 21, 1918, and—																	
		Sept. 1, 1918. (2.5 mos.)	Oct. 1, 1918. (3.5 mos.)	Nov. 1, 1918. (4.5 mos.)	Dec 1, 1918. (5.5 mos.)	Jan. 1, 1919. (6.5 mos.)	Feb. 1, 1919. (7.5 mos.)	Mar. 1, 1919. (8.5 mos.)	Apr. 1, 1919. (9.5 mos.)	May 1, 1919. (10.5 mos.)	June 1, 1919. (11.5 mos.)	July 1, 1919. (12.5 mos.)	Aug. 1, 1919. (13.5 mos.)	Sept. 1, 1919. (14.5 mos.)	Oct. 1, 1919. (15.5 mos.)	Nov. 1, 1919. (16.5 mos.)	Dec. 1, 1919. (17.5 mos.)	Jan. 1, 1920. (18.5 mos.)	Feb 15 1920. (20 mos.)	Apr. 1, 1920. (21.5 mos.)
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
RXP.....	166	.....	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1.8	1.8	1.8	1.8	2.4	3.6	4.8	6.0	6.0	6.0
TXP.....	164	.....	.....	.....	.....	.....	.....	.....	.....	.....	.6	.6	.6	.6	.6	.6	4.3	4.3	4.3	4.3
RAP.....	167	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.6	1.8	2.4	2.4	2.4
TAP.....	166	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.6	3.0	3.6	4.8	5.4
RXN.....	337	0.6	2.4	4.7	14.5	23.1	32.7	66.7	71.5	74.7	78.0	78.7	84.3	85.5	87.3	88.8	90.5	91.1	91.5	92.1
TXN.....	336	.....	.6	3.3	7.7	16.4	21.4	53.5	58.9	64.9	71.1	72.1	77.1	82.0	84.3	86.7	88.2	89.9	91.1	92.3
RAN.....	336	.....	.6	2.7	5.7	10.4	13.7	50.1	59.6	65.6	69.5	73.5	78.6	80.3	83.0	85.7	87.3	89.0	89.6	90.3
TAN.....	335	.....	1.2	4.2	8.1	12.8	15.2	50.2	56.4	62.3	65.6	66.5	71.3	75.3	76.1	77.7	80.6	82.4	83.3	85.0

TABLE 108.—PERCENTAGE OF FAILURES, DURING SPECIFIED PERIODS, IN CANS OF REGULAR AND OF TITANIUM-TREATED PLATE, 1917 EXPERIMENT, AVERAGE OF ALL HEATS: AVERAGE[a] OF ALL PRODUCTS.

Code mark.	Number of cans.	Percentage of failures in cans packed—															
		2.5 mos.	3.5 mos.	4.5 mos.	5.5 mos.	6.5 mos.	8.5 mos.	9.5 mos.	10.5 mos.	11.5 mos.	12.5 mos.	13.5 mos.	14.5 mos.	15.5 mos.	16.5 mos.	17.5 mos.	19.5 mos.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct*	*P. ct.*	*P. ct.*	*P. ct.*
RXP.....	838	.....	0.1	0.2	0.2	0.2	0.8	1.9	2.3	4.3	6.6	8.7	10.4	13.2	20.5	23.8	28.4
TXP.....	835	.....	.....	.....	.1	.2	.4	.7	.8	1.3	1.3	2.4	3.0	4.3	9.0	12.3	15.4
RAP.....	835	.....	.....	.....	.....	.....	.4	.7	1.2	3.1	5.9	7.4	9.1	11.9	17.4	20.8	25.2
TAP.....	838	.....	.....	.....	.....	.....	.....	.....	.....	.1	.7	1.6	2.3	3.1	7.5	9.7	14.3
RXN.....	1006	0.2	0.8	4.2	11.6	29.1	55.3	62.8	67.1	73.6	79.7	82.8	84.7	88.1	90.1	92.3	93.4
TXN.....	1004	.....	.2	2.4	6.0	22.5	42.4	50.1	56.0	63.5	68.8	72.5	76.2	79.9	84.4	87.1	91.3
RAN.....	1004	.....	.3	2.3	5.3	14.4	35.6	44.2	51.2	56.7	63.8	68.1	72.5	77.2	81.6	85.1	88.1
TAN.....	994	.....	.5	2.1	4.4	10.5	29.7	34.6	40.6	47.5	52.6	56.7	60.6	65.3	70.7	76.3	80.6

[a] In computing this average, the sum of the failures for each product for equal months of storage was divided by the total number of cans packed, except in two instances, one with blueberries, where an 18 months' period of storage was averaged with 17.5 months of the other produets; the other with strawberries where 20 months' period of storage was averaged with 19.5 months for the other products. This same method of averaging was used for all averages of all products of the 1917 experiment.

TABLE 109.—PERCENTAGE OF FAILURES, DURING SPECIFIED PERIODS, IN ENAMELED CANS OF REGULAR AND OF TITANIUM-TREATED PLATE, 1919 EXPERIMENT: CIDER.

Code mark.	Number of cans.	Percentage of failures between date of packing, Nov. 17, 1919, and—											
		Apr. 1, 1920 (4.5 mos.).	May 1, 1920 (5.5 mos.).	June 1, 1920 (6.5 mos.).	July 1, 1920 (7.5 mos.).	Aug. 1, 1920 (8.5 mos.).	Sept. 1, 1920 (9.5 mos.).	Oct. 1, 1920 (10.5 mos.).	Nov. 1, 1920 (11.5 mos.).	Dec. 1, 1920 (12.5 mos.).	Jan. 1, 1920 (13.5 mos.).	Feb. 1, 1921 (14.5 mos.).	Mar. 1, 1921 (15.5 mos.).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R21XN	95	1.1	8.4	61.1	69.5	88.4	97.9	98.9	100.0	.....	.....	.....	.....
T21XN	96	.....	.....	1.0	38.6	67.7	79.2	84.4	89.6	91.7	95.8	96.8	99.0
CR21N	96	1.0	1.0	12.5	52.1	86.5	96.9	96.9	97.9	97.9	97.9	97.9	97.9
CT21N	96	1.0	1.0	1.0	17.7	54.2	77.1	87.5	90.7	95.8	97.9	100.0	.....
R22XN	95	5.3	31.6	55.8	72.7	86.3	95.8	100.0	.....	.....	.....	.....	.....
T22XN	96	.....	21.9	58.3	80.2	95.8	97.9	100.0	.....	.....	.....	.....	.....
CR22XN	96	.....	1.0	17.7	42.8	50.0	56.3	74.0	86.5	90.7	91.7	96.9	97.9
CT22XN	96	.....	.....	.....	18.7	37.5	54.2	76.0	85.4	91.7	95.8	99.0	99.0
R23XN	95	.....	5.3	30.5	56.8	91.6	98.9	100.0	.....	.....	.....	.....	.....
T23XN	96	.....	2.1	20.8	37.3	47.9	67.7	77.1	82.3	89.6	90.6	94.8	97.9
CR23XN	73	.....	.....	2.7	6.9	20.5	26.0	46.6	57.6	67.2	67.2	69.8	78.2
CT23XN	96	.....	.....	.....	3.1	9.4	12.5	31.3	40.7	46.8	48.9	52.1	59.4
R24XN	96	25.0	51.1	73.0	82.3	100.0	.....	.....	.....	.....	.....	.....	.....
T24XN	96	2.1	33.3	59.4	72.9	90.7	99.0	100.0	.....	.....	.....	.....	.....
CR24XN	96	2.1	4.2	29.2	36.5	44.8	50.0	60.4	63.6	70.8	76.1	81.3	84.4
CT24XN	96	.....	.....	.....	26.0	45.8	62.5	68.8	74.0	82.3	92.7	93.8	93.8
All RXN	381	7.9	24.1	55.1	70.4	91.6	98.2	99.7	100.0	.....	.....	.....	.....
All TXN	384	.5	14.3	34.9	57.3	75.6	86.0	90.4	93.0	95.3	96.7	97.9	99.3
All CRXN	361	.8	1.7	16.3	36.3	52.4	59.3	70.9	77.6	82.6	84.2	87.5	90.3
All CTXN	384	.3	.3	.3	16.4	26.7	51.6	65.9	72.7	79.2	83.9	86.2	88.1

TABLE 110.—PERCENTAGE OF FAILURES, DURING SPECIFIED PERIODS, IN ENAMELED CANS OF REGULAR AND OF TITANIUM-TREATED PLATE, 1919 EXPERIMENT: BLUEBERRIES.

Code mark.	Number of cans.	Percentage of failures between date of packing, Aug. 12, 1919, and—											
		Apr. 1, 1920 (7.5 mos.).	May 1, 1920 (8.5 mos.).	June 1, 1920 (9.5 mos.).	July 1, 1920 (10.5 mos.).	Aug. 1, 1920 (11.5 mos.).	Sept. 1, 1920 (12.5 mos.).	Oct. 1, 1920 (13.5 mos.).	Nov. 1, 1920 (14.5 mos.).	Dec. 1, 1920 (15.5 mos.).	Jan. 1, 1921 (16.5 mos.).	Feb. 1, 1921 (17.5 mos.).	Mar. 1, 1921 (18.5 mos.).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R21XN....	48	.....	4.2	6.3	6.3	20.8	27.1	33.3	35.4	39.6	41.7	45.8	47.9
T21XN....	48	.....	.....	.....	.....	.....	.....	.....	4.2	6.3	6.3	6.3	12.5
CR21XN..	48	.....	2.1	12.5	12.5	20.8	27.1	41.7	47.9	52.1	54.2	58.3	64.6
CT21XN...	48	.....	.....	.....	.....	.....	12.5	22.9	22.9	27.1	31.3	45.8	47.9
R22XN....	48	.....	2.1	18.8	43.8	54.2	60.4	62.5	64.6	64.6	75.0	77.1	81.3
T22XN....	48	.....	.....	.....	.....	12.5	25.0	37.5	41.7	43.8	45.8	47.9	52.1
CR22XN..	48	4.2	4.2	20.8	33.3	62.5	75.0	91.7	91.7	91.7	95.8	95.8	95.8
CT22XN...	48	2.1	2.1	4.2	4.2	31.3	43.8	52.1	58.3	62.5	68.8	72.9	75.0
R23XN....	48	.....	.....	.....	2.1	20.8	33.3	47.9	58.3	62.5	64.6	66.7	68.8
T23XN....	48	.....	.....	.....	4.2	6.3	25.0	31.3	31.3	35.4	37.5	39.6	41.7
CR23XN..	48	2.1	2.1	2.1	4.2	18.8	43.8	52.1	54.2	58.3	58.3	60.4	60.4
CT23XN...	48	.....	.....	.....	.....	8.3	27.1	33.3	33.3	37.5	37.5	41.7	43.8
R24XN....	48	18.8	18.8	41.7	45.8	52.1	64.6	70.8	77.1	79.2	81.3	85.4	87.5
T24XN....	48	.....	.....	.....	.....	.....	16.7	22.9	25.0	29.2	31.3	41.7	41.7
CR24XN..	48	16.7	22.9	60.4	64.6	75.0	85.4	85.4	87.5	91.7	91.7	95.8	95.8
CT24XN...	48	2.1	2.1	2.1	6.3	25.0	43.8	50.0	52.1	54.2	56.2	58.3	60.4
All RXN...	192	4.7	6.3	16.7	24.5	37.0	46.3	53.6	58.9	61.5	65.6	68.8	**71.3**
All TXN...	192	.....	.....	.....	1.0	4.7	16.7	22.9	25.5	28.6	30.2	33.9	37.0
All CRXN.	192	5.7	7.8	22.4	26.0	41.1	54.2	62.5	67.2	**71.9**	**74.5**	77.1	78.6
All CTXN.	192	1.0	**1.0**	1.6	2.6	16.1	31.8	39.6	41.7	45.3	48.4	54.7	56.8

TABLE 111.—PERCENTAGE OF FAILURES, DURING SPECIFIED PERIODS, IN ENAMELED CANS OF REGULAR AND OF TITANIUM-TREATED PLATE, 1919 EXPERIMENT: PEACHES.

Code mark.	Number of cans.	Percentage of failures between date of packing, Sept. 9, 1919, and—											
		Apr. 1, 1920 (6.5 mos.).	May 1, 1920 (7.5 mos.).	June 1, 1920 (8.5 mos.).	July 1, 1920 (9.5 mos.).	Aug. 1, 1920 (10.5 mos.).	Sept. 1, 1920 (11.5 mos.).	Oct. 1, 1920 (12.5 mos.).	Nov. 1, 1920 (13.5 mos.).	Dec. 1, 1920 (14.5 mos.).	Jan. 1, 1921 (15.5 mos.).	Feb. 1, 1921 (16.5 mos.).	Mar. 1, 1921 (17.5 mos.).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R21XN....	48	.....	.....	2.1	8.3	20.8	25.0	29.2	35.4	37.5	41.7	45.8	50.0
T21XN....	47	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1	2.1	2.1
CR21XN..	48	2.1	2.1	2.1	8.3	8.3	12.5	20.8	22.9	35.4	45.8	56.2	60.4
CT21XN...	46	.....	.....	.....	.....	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
R22XN....	48	27.1	50.0	68.8	77.1	83.3	85.4	85.4	85.4	85.4	85.4	85.4	85.4
T22XN....	48	2.1	4.2	22.9	43.8	50.0	60.4	64.6	64.6	66.7	66.7	66.7	66.7
CR22XN..	48	.....	.....	.....	2.1	6.3	14.6	29.2	33.3	41.7	43.8	45.8	47.9
CT22XN...	46	.....	.....	.....	.....	2.1	8.3	12.5	16.7	16.7	20.8	22.9	22.9
R23XN....	48	2.1	2.1	6.3	10.4	22.9	35.4	39.6	45.8	47.9	50.0	52.1	54.2
T23XN....	48	.....	.....	.....	.....	2.1	6.3	10.4	16.7	16.7	16.7	16.7	16.7
CR23XN..	45	.....	.....	.....	.....	.....	.....	.....	2.2	2.2	4.4	4.4	8.9
CT23XN...	48	.....	.....	.....	.....	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
R24XN....	47	34.1	53.2	59.6	76.6	89.4	91.5	95.7	97.9	97.9	97.9	97.9	97.9
T24XN....	46	.....	.....	6.5	8.7	32.6	45.7	52.2	54.4	56.5	56.5	58.7	58.7
CR24XN..	47	6.4	8.5	8.5	8.5	8.5	19.2	19.2	21.3	25.5	29.8	40.4	46.8
CT24XN...	48	.....	.....	.....	4.2	4.2	4.2	6.3	8.3	8.3	14.6	16.7	22.9
All RXN...	191	15.7	26.2	34.0	42.9	53.9	59.2	62.3	66.0	67.1	68.6	70.2	71.8
All TXN...	189	.5	1.1	7.4	13.8	22.2	29.1	33.3	33.9	34.9	35.4	35.9	35.9
All CRXN.	188	2.1	2.7	2.7	4.8	5.9	11.7	17.6	20.2	26.6	31.4	37.2	41.5
All CTXN.	190	.....	.....	.....	1.1	3.2	4.7	6.3	7.9	7.9	10.5	11.6	13.2

TABLE 112.—PERCENTAGE OF FAILURES, DURING SPECIFIED PERIODS, IN ENAMELED CANS OF REGULAR AND OF TITANIUM-TREATED PLATE, 1919 EXPERIMENT: BLACK RASPBERRIES.

Code mark.	Number of cans.	Percentage of failures between date of packing, July 17, 1919, and—											
		Apr. 1, 1920 (8.5 mos.).	May 1, 1920 (9.5 mos.).	June 1, 1920 (10.5 mos.).	July 1, 1920 (11.5 mos.).	Aug. 1, 1920 (12.5 mos.).	Sept. 1, 1920 (13 5 mos.).	Oct. 1, 1920 (14.5 mos.).	Nov. 1, 1920 (15.5 mos.).	Dec. 1, 1920 (16.5 mos.).	Jan. 1, 1921 (17.5 mos.).	Feb. 1, 1921 (18.5 mos.).	Mar. 1, 1921 (19.5 mos.).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R21XN....	48	.....	.....	.....	.....	6.3	12.5	12.5	20.8	20.8	25.0	25.0	29.2
T21XN....	47	.....	.....	.....	.....	.....	8.5	12.8	12.8	12.8	17.0	21.3	25.5
CR21XN..	48	6.3	6.3	6.3	6.3	27.1	35.4	41.7	54.2	62.5	70.8	75.0	77.1
CT21XN...	48	.....	.....	.....	.....	4.2	14.6	22.9	29.2	29.2	29.2	35.4	43.8
R22XN....	47	.....	.....	.....	4.3	29.8	44.7	53.2	57.5	61.7	85.1	87.2	93.6
T22XN....	47	.....	.....	.....	.....	14.9	21.3	36.2	40.4	40.4	48.9	53.2	61.7
CR22XN..	48	.....	.....	.....	10.4	31.3	43.8	54.2	60.4	64.6	79.2	79.2	85.4
CT22XN...	47	.....	.....	.....	.....	23.4	38.3	42.6	57.5	61.7	70.2	70.2	70.2
R23XN....	48	.....	.....	.....	.....	8.3	12.5	18.8	20.8	27.1	45.8	45.8	54.2
T23XN....	47	.....	.....	.....	.....	6.4	8.5	12.8	17.0	17.0	21.3	23.4	27.7
CR23XN..	47	.....	.....	.....	.....	8.5	10.6	21.3	29.8	36.2	36.2	36.2	42.6
CT23XN...	48	.....	.....	.....	.....	6.3	8.3	20.8	22.9	27.1	35.4	37.5	45.8
R24XN....	46	.....	.....	.....	6.5	47.8	60.9	73.9	78.2	80.4	86.9	86.9	88.1
T24XN....	48	.....	.....	.....	.....	29.2	52.1	56.2	62.5	70.8	72.9	72.9	79.2
CR24XN..	46	.....	2.2	2.2	6.5	50.0	58.7	67.4	69.6	73.9	80.4	84.8	88.1
CT24XN...	47	.....	.....	.....	2.1	17.0	25.5	46.8	59.6	66.0	72.4	78.7	89.4
All RXN...	189	.....	.....	.....	2.6	22.7	32.3	39.1	43.9	47.1	60.3	60.8	66.1
All TXN...	189	.....	.....	.....	.....	12.7	22.7	29.6	33.3	35.4	40.2	42.8	48.6
All CRXN.	189	1.6	2.1	2.1	5.8	29.1	37.0	46.0	53.4	59.3	66.7	68.8	73.6
All CTXN.	190	.....	.....	.....	.5	12.6	21.6	33.2	42.1	45.8	51.6	55.2	62.1

TABLE 113.—PERCENTAGE OF FAILURES, AT SPECIFIED DATES, IN ENAMELED CANS OF REGULAR AND OF TITANIUM-TREATED PLATE, 1919 EXPERIMENT: AVERAGE [a] OF ALL PRODUCTS.

Code mark.	Number of cans.	Average percentage of failures on—											
		Apr. 1, 1920	May 1, 1920	June 1, 1920	July 1, 1920	Aug. 1, 1920	Sept. 1, 1920	Oct. 1, 1920	Nov. 1, 1920	Dec. 1, 1920	Jan. 1, 1921	Feb. 1, 1921	Mar. 1, 1921
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R21XN....	192	0.5	3.1	17.2	20.8	33.8	40.6	43.2	47.9	49.5	52.1	54.2	56.8
T21XN....	190	.....	.....	.5	10.0	17.4	22.1	24.8	26.9	27.9	30.5	32.1	35.3
CR21XN..	192	2.6	3.1	8.3	19.8	35.9	43.2	50.5	55.8	62.0	67.2	71.9	75.0
CT21XN...	190	.5	.5	.5	4.7	15.8	27.4	34.7	37.4	39.5	41.1	46.8	49.4
R22XN....	191	8.4	20.9	36.1	49.8	63.4	71.8	75.4	77.0	78.0	86.4	87.5	90.1
T22XN....	191	.5	6.8	20.4	29.3	41.4	47.6	55.5	57.6	58.7	61.3	62.8	66.0
CR22XN..	192	1.0	1.6	8.3	19.8	34.4	43.8	57.3	65.1	70.9	77.1	79.2	81.3
CT22XN...	191	.5	.5	1.0	5.8	23.6	36.1	46.6	54.4	58.1	63.9	66.5	67.0
R23XN....	192	.5	2.1	9.4	17.2	35.9	44.8	51.6	56.3	59.4	65.1	66.2	69.3
T23XN....	191	.....	.5	5.2	11.0	16.7	28.3	33.5	36.1	38.8	40.8	42.9	45.0
CR23XN..	177	.6	.6	1.1	2.8	11.9	20.2	29.4	35.0	40.2	40.7	41.8	46.3
CT23XN...	192	.....	.....	.....	1.0	6.8	12.5	21.9	25.0	28.7	31.2	33.3	38.0
R24XN....	189	19.6	31.2	43.9	53.5	72.5	79.4	85.2	88.4	89.4	91.6	92.6	93.7
T24XN....	190	.5	8.4	16.8	20.5	38.4	51.6	55.3	57.9	61.6	62.6	65.3	66.9
CR24XN..	189	6.4	9.5	25.4	29.6	45.0	53.4	58.2	60.8	65.6	69.8	75.6	79.4
CT24XN...	191	.5	.5	.5	9.9	23.0	34.0	42.9	48.7	52.9	59.2	61.8	66.5
All RXN...	764	7.2	14.3	26.6	35.2	51.3	59.1	63.8	67.3	69.0	73.5	75.0	77.4
All TXN...	762	.3	3.9	11.8	17.7	28.5	37.5	42.3	44.7	46.8	48.8	50.8	53.3
All CRXN.	750	2.7	3.7	10.9	18.3	32.1	40.6	49.2	54.5	60.0	64.2	67.6	71.0
All CTXN..	764	.4	.4	.5	5.4	17.3	27.5	36.4	41.4	44.8	48.9	52.1	55.2

[a] In the 1919 experiment, the sum of the failures (with the exception of cider where the number was divided by two as twice as many cider cans were packed as other products) for each product at each inspection period was divided by the total number of cans (one-half the number of cider cans being used in obtaining this total) to secure the averages. The averages were made by inspection periods rather than on the basis of months of storage after date of packing as was done in the 1917 experiment. This was done because the length of time after storage before perforation commenced was so different for the different products. This same method of averaging was used for all averages of all products of the 1919 experiment.

TABLE 114.—PERCENTAGE OF FAILURES, AT SPECIFIED DATES IN CANS OF SILICON-TREATED REGULAR AND TITANIUM PLATE, 1919 EXPERIMENT: AVERAGE OF ALL PRODUCTS.

Code mark.	Number of cans.	Percentage of failures on—											
		Apr. 1, 1920	May 1, 1920	June 1, 1920	July 1, 1920	Aug. 1, 1920	Sept. 1, 1920	Oct. 1, 1920	Nov. 1, 1920	Dec. 1, 1920	Jan. 1, 1921	Feb. 1, 1921	Mar. 1, 1921
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
SR21XN...	192	28.7	38.6	49.0	57.3	64.6	70.8	72.4	76.6	80.7	84.4	87.6	91.2
ST21XN...	188	1.6	1.6	12.2	21.8	31.4	36.7	38.8	42.0	46.8	49.5	53.2	61.7
SCR21XN.	191	11.5	18.7	30.7	49.0	59.4	68.8	70.9	75.6	78.7	81.8	86.0	89.1
SCT21XN.	191	.....	1.6	5.8	16.8	28.3	31.4	36.1	43.5	50.3	51.8	56.0	64.4
SR22XN...	191	73.3	80.6	83.8	92.7	94.8	95.8	97.4	97.4	97.4	97.9	97.9	97.9
ST22XN...	190	37.9	48.9	57.4	68.5	78.5	86.3	90.1	93.2	94.8	96.4	96.8	98.5
SCR22XN.	191	19.4	28.8	50.3	67.5	82.7	92.7	95.8	95.8	96.3	98.5	98.5	99.5
SCT22XN.	192	.5	1.0	2.6	12.0	25.5	28.6	47.9	57.3	62.0	66.7	70.3	76.1
SR23XN...	191	8.9	15.2	29.3	53.9	68.1	74.4	79.1	81.7	86.4	90.1	91.2	92.7
ST23XN...	191	13.1	21.5	35.1	51.3	58.1	67.5	71.2	74.9	82.2	85.9	89.6	91.7
SCR23XN.	192	.5	1.6	1.6	3.1	16.7	26.8	36.5	40.7	46.8	52.1	56.8	61.5
SCT23XN.	192	.....	.....	.....	1.0	7.8	15.1	21.9	32.8	37.5	46.3	50.5	56.3
SR24XN...	192	41.7	58.9	71.4	77.6	91.7	92.8	94.8	95.4	97.4	97.4	97.4	97.4
ST24XN...	192	34.4	44.8	57.8	70.8	79.7	84.9	88.0	91.2	93.8	93.8	94.3	95.3
SCR24XN.	191	2.1	3.7	9.4	22.0	47.1	56.0	69.6	80.7	83.2	86.9	88.0	88.5
SCT24XN.	190	2.6	3.2	10.0	20.5	33.7	49.0	61.6	74.2	79.5	83.2	84.8	86.3
All SRXN..	766	38.1	48.3	58.4	70.5	79.8	83.5	86.0	87.8	90.5	92.5	93.5	94.8
All STXN..	761	21.8	29.3	40.8	53.2	62.1	69.0	72.2	75.5	79.5	81.5	83.6	86.9
All SCRXN	766	8.4	13.2	23.0	35.4	51 4	61.0	68.1	73.1	76.3	79.9	82.3	84.7
All SCTXN	765	.8	1.4	4.6	12.5	23.8	33.5	41.8	52.0	57.4	62.0	65.4	70.7

APPENDIX XXX.—FAILURES IN LOTS OF EXPERIMENTAL AND COMMERCIAL PLATE IN 1917.

TABLE 115.—PERCENTAGE OF FAILURES, DURING SPECIFIED PERIODS, IN CANS OF ALL HEATS OF EXPERIMENTAL AND ALL LOTS OF COMMERCIAL PLATE, 1917 EXPERIMENT: AVERAGE OF ALL PRODUCTS.

Code mark.	Number of cans.	Percentage of failures in cans packed—															
		2.5 mos.	3.5 mos.	4.5 mos.	5.5 mos.	6.5 mos.	8.5 mos.	9.5 mos.	10.5 mos.	11.5 mos.	12.5 mos.	13.5 mos.	14.5 mos.	15.5 mos.	16.5 mos.	17.5 mos.	19.5 mos.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct*
RXP	838	.....	0.1	0.2	0.2	0.2	0.8	1.9	2.3	4.3	6.6	8.7	10.4	13.2	20.5	23.8	28.4
TXP	835	.....	.....	.....	.1	.2	.4	.7	.8	1.3	1.3	2.4	3.0	4.3	9.0	12.3	15.4
BXP	477	.....	.....	.2	.2	.2	.4	.4	.4	1.9	3.6	4.6	6.3	8.0	10.1	12.0	14.3
HXP	393	.....	.....	.....	.3	.5	1.5	2.3	2.5	3.1	4.3	6.9	7.4	8.7	11.0	13.2	20.1
RAP	835	.....	.....	.....	.....	.....	.4	.7	1.2	3.1	5.9	7.4	9.1	11.9	17.4	20.8	25.2
TAP	838	.....	.....	.....	.....	.....	.....	.....	.....	.1	0.7	1.6	2.3	3.1	7.5	9.7	14.3
BAP	216	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.4	.8	1.3	5.0	6.7
HAP	286	.....	.....	.....	.....	.....	.....	.....	.....	.3	.7	.7	.7	1.0	1.0	2.4	4.5
RXN	1,006	0.2	.8	4.2	11.6	29.1	55.3	62.8	67.1	73.6	79.7	82.8	84.7	88.1	90.1	92.3	93.4
TXN	1,004	.....	.2	2.4	6.0	22.5	42.4	50.1	56.0	63.5	68.8	72.5	76.2	79.9	84.4	87.1	91.3
BXN	567	.....	.4	.9	6.2	13.4	33.5	40.9	45.7	52.6	58.2	63.0	66.7	69.9	72.7	76.5	80.3
HXN	575	.....	1.7	2.3	7.3	16.2	33.6	43.3	47.3	52.9	59.0	64.9	67.0	69.9	75.8	80.9	85.7
RAN	1,004	.....	.3	2.3	5.3	14.4	35.6	44.2	51.2	56.7	63.8	68.1	72.5	77.2	81.6	85.1	88.1
TAN	994	.....	.5	2.1	4.4	10.5	27.9	34.6	40.6	47.5	52.6	56.7	60.6	65.3	70.7	76.3	80.6
BAN	285	.....	.....	.....	.....	1.1	5.6	9.5	11.6	16.8	18.3	21.4	24.2	28.4	30.5	33.0	36.5
HAN	423	.....	.....	.....	.2	.7	4.5	7.6	9.2	13.5	15.8	18.9	23.2	26.0	31.7	36.4	41.8

APPENDIX XXXI.—FAILURES AS AFFECTED BY USE OF SILICON IN THE MOLD AS A DEOXIDIZER.

TABLE 116.—PERCENTAGE OF FAILURES, AT SPECIFIED DATES, IN CANS OF SILICON-TREATED AND NON-SILICON-TREATED PLATE, 1919 EXPERIMENT, AVERAGE OF ALL HEATS, ALL TYPES OF PLATE, AND ALL PRODUCTS.

Type of plate.	Number of cans.	Percentage of failures on—											
		Apr. 1, 1920	May 1, 1920	June 1, 1920	July 1, 1920	Aug. 1, 1920	Sept. 1, 1920	Oct. 1, 1920	Nov. 1, 1920	Dec. 1, 1921	Jan. 1, 1921	Feb. 1, 1921	Mar. 1, 1921
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
All RXN	764	7.2	14.3	26.6	35.2	51.3	59.1	63.8	67.3	69.0	73.7	75.0	77.4
All SRXN	766	38.1	48.3	58.4	70.5	79.8	83.5	86.0	87.8	90.5	92.5	93.5	94.8
All CRXN	750	2.7	3.7	10.9	18.3	32.1	40.6	49.2	54.5	60.0	64.2	67.6	71.0
All SCRXN	766	8.4	13.2	23.0	35.4	51.4	61.0	68.1	73.1	76.3	79.9	82.3	84.7
All TXN	762	.3	3.9	11.8	17.7	28.5	37.5	42.3	44.7	46.8	48.8	50.8	53.3
All STXN	761	21.8	29.3	40.8	53.2	62.1	69.0	72.2	75.5	79.5	81.5	83.6	86.9
All CTXN	764	.4	.4	.5	5.4	17.3	27.5	36.4	41.4	44.8	48.9	52.1	55.2
All SCTXN	765	.8	1.4	4.6	12.5	23.8	33.5	41.8	52.0	57.4	62.0	65.4	70.7

APPENDIX XXXII.—FAILURES AS AFFECTED BY THE WEIGHT OF TIN COATING.

TABLE 117.—PERCENTAGE OF FAILURES, DURING SPECIFIED PERIODS, IN ENAMELED CANS OF QUARTER-INGOT LOTS OF REGULAR AND TITANIUM-TREATED PLATE WITH DIFFERENT WEIGHTS OF TIN COATING, 1917 EXPERIMENT, AVERAGE OF ALL PRODUCTS.

Type of plate.	Number of cans.	Percentage of failures in cans packed—														
		3.5 mos.	4.5 mos.	5.5 mos.	6.5 mos.	8.5 mos.	9.5 mos.	10.5 mos.	11.5 mos.	12.5 mos.	13.5 mos.	14.5 mos.	15.5 mos.	16.5 mos.	17.5 mos.	19.5 mos.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Enameled cans of R3 with an average coating of:																
1.51 pounds per base box	142	.....	.....	0.7	7.6	34.0	40.3	45.8	57.6	61.8	68.1	70.2	77.8	83.3	86.2	89.6
2.19 pounds per base box	142	.....	0.7	.7	6.3	23.1	30.3	38.0	45.1	51.3	56.3	59.1	62.6	66.2	69.7	76.7
3.84 pounds per base box	144	.....	.....	.....	.....	11.1	13.9	16.0	18.0	18.7	22.0	25.0	28.5	31.9	34.0	43.1
Enameled cans of T4 with an average coating of:																
1.50 pounds per base box	143	.....	2.1	7.6	31.3	61.8	71.6	77.8	83.3	90.3	93.1	94.4	96.6	97.9	97.9	99.3
2.24 pounds per base box	143	1.4	4.2	9.1	16.8	44.8	56.7	63.0	68.5	75.6	79.8	85.3	91.6	96.6	97.9	98.6
3.11 pounds per base box	144	.....	.....	.....	.7	11.1	13.2	16.7	22.2	25.0	31.3	33.4	43.1	45.2	56.2	65.3

APPENDIX XXXIII.—VARIATIONS IN FAILURES BY HEATS OF STEEL.

TABLE 118.—PERCENTAGE OF FAILURES, DURING SPECIFIED PERIODS, IN ENAMELED CANS OF EACH HEAT OF 1917 EXPERIMENTAL PLATE, AVERAGE OF ALL PRODUCTS.

Code mark.	Number of cans.	Percentage of failures in cans packed—															
		2.5 mos.	3.5 mos.	4.5 mos.	5.5 mos.	6.5 mos.	8.5 mos.	9.5 mos.	10.5 mos.	11.5 mos.	12.5 mos.	13.5 mos.	14.5 mos.	15.5 mos.	16.5 mos.	17.5 mos.	19.5 mos.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
R1XN	141	.....	.....	.....	2.8	15.6	31.2	48.2	52.5	60.3	68.8	75.2	81.6	83.0	85.1	87.3	88.0
R2XN	144	2.8	6.3	16.0	27.1	54.2	78.5	86.8	93.1	97.9	98.6	98.6	98.6	98.6	100.0	.....	.....
R3XN	144	.....	.....	.....	.7	7.6	34.0	40.3	45.8	57.6	61.8	68.1	70.2	77.8	83.3	86.2	89.6
R4XN	144	.....	.....	6.3	16.7	29.0	68.1	74.3	81.9	86.8	95.8	96.5	97.9	97.9	98.7	99.3	99.3
R5XN	143	.....	.....	.....	.....	14.0	30.1	36.4	39.9	46.8	53.2	58.1	59.4	61.6	69.2	72.8	79.1
R6XN	144	.....	.7	4.2	13.2	34.7	64.6	72.2	75.0	78.5	86.8	90.3	91.0	95.8	97.9	99.3	99.3
R7XN	144	.....	.....	2.8	20.8	48.6	75.7	81.2	82.7	87.5	94.5	95.2	96.6	97.9	98.6	100.0	.....
R1AN	143	.....	.....	.....	.....	2.8	6.3	9.8	14.0	21.7	33.6	41.9	50.3	60.2	70.0	76.3	81.2
R2AN	143	.....	1.4	6.3	12.6	30.8	57.3	68.5	76.3	84.7	88.8	91.0	93.0	94.5	96.6	97.9	98.6
R3AN	142	.....	.....	.7	.7	6.3	23.1	30.3	38.0	45.1	51.3	56.3	59.1	62.6	66.2	69.7	76.7
R4AN	144	.....	.....	.....	1.4	9.0	45.8	61.1	71.5	78.5	86.8	88.2	89.6	94.5	97.9	98.6	99.3
R5AN	144	.....	.....	.....	.....	.....	13.9	20.2	25.0	29.9	34.7	41.0	45.8	54.2	56.9	66.0	71.6
R6AN	137	.....	.7	8.8	19.0	27.3	65.0	70.1	71.5	75.2	79.6	82.5	84.7	90.5	96.3	97.8	99.3
R7AN	144	.....	.....	.7	2.8	14.6	41.7	51.4	61.1	65.3	75.0	79.2	81.9	87.5	92.3	93.1	94.4
T1XN	143	.....	.....	.7	.7	5.6	14.7	17.5	23.1	32.9	39.2	41.3	50.3	54.6	67.8	76.3	81.8
T2XN	143	.....	.....	.....	.....	9.1	20.3	27.3	35.7	48.3	54.6	61.6	65.8	70.0	76.3	80.5	89.6
T3XN	143	.....	.....	.7	.7	14.7	25.9	32.9	43.4	50.4	53.8	58.8	62.2	67.2	70.7	71.3	77.6
T4XN	144	.....	.....	2.1	7.6	31.3	61.8	71.6	77.8	83.3	90.3	93.1	94.4	96.6	97.9	97.9	99.3
T5XN	144	.....	.....	2.1	14.6	38.2	59.7	70.1	74.3	82.0	88.9	90.3	91.7	94.5	95.8	95.8	97.2
T6XN	143	.....	1.4	8.4	15.4	32.2	58.7	67.2	70.0	74.9	77.7	81.8	85.3	91.0	93.0	95.8	97.9
T7XN	143	.....	.....	2.8	8.4	26.6	52.4	60.2	67.2	72.1	78.3	81.8	83.9	87.5	91.0	94.5	97.2
T1AN	143	.....	.....	.....	.7	1.4	2.1	3.5	5.6	15.4	16.1	18.2	21.0	27.3	30.8	36.4	46.1
T2AN	144	.....	.....	.....	.....	4.9	16.7	20.8	25.0	31.9	34.7	41.0	45.1	51.4	54.2	64.6	75.0
T3AN	142	.....	.....	.7	.7	2.1	7.8	14.8	21.8	31.7	43.0	45.8	50.0	51.4	54.2	59.8	65.5
T4AN	143	.....	1.4	4.2	9.1	16.8	44.8	56.7	63.0	68.5	75.6	79.8	85.3	91.6	96.6	97.9	98.6
T5AN	144	.....	1.4	5.6	11.8	18.8	41.0	52.8	59.7	66.7	69.5	75.0	80.6	84.0	92.4	94.4	95.2
T6AN	142	.....	.....	3.5	7.7	17.6	47.9	54.2	60.5	63.3	66.9	71.2	72.6	78.8	85.9	91.6	95.1
T7AN	136	.....	.7	.7	.7	5.9	32.4	39.7	48.5	55.1	63.3	65.5	66.9	72.7	80.9	89.0	91.9

TABLE 119.—PERCENTAGE OF FAILURES, AT SPECIFIED DATES, IN ENAMELED CANS OF EACH HEAT OF 1919 EXPERIMENTAL PLATE, AVERAGE OF ALL PRODUCTS.

Code mark.	Number of cans.	Percentage of failures on—											
		Apr. 1, 1920.	May 1, 1920.	June 1, 1920.	July 1, 1920.	Aug. 1, 1920.	Sept. 1, 1920.	Oct. 1, 1920.	Nov. 1, 1920.	Dec. 1, 1920.	Jan. 1, 1921.	Feb. 1, 1921.	Mar. 1, 1921.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R21XN	192	0.5	3.1	17.2	20.8	33.8	40.6	43.2	47.9	49.5	52.1	54.2	56.8
R22XN	191	8.4	20.9	36.1	49.8	63.4	71.8	75.4	77.0	78.0	86.4	87.5	90.1
R23XN	192	.5	2.1	9.4	17.2	35.9	44.8	51.6	56.3	59.4	65.1	66.2	69.3
R24XN	189	19.6	31.2	43.9	53.5	72.5	79.4	85.2	88.4	89.4	91.6	92.6	93.7
T21XN	190	.....	.....	.5	10.0	17.4	22.1	24.8	26.9	27.9	30.5	32.1	35.3
T22XN	191	.5	6.8	20.4	29.3	41.4	47.6	55.5	57.6	58.7	61.3	62.8	66.0
T23XN	191	.....	.5	5.2	11.0	16.7	28.3	33.5	36.1	38.8	40.8	42.9	45.0
T24XN	190	.5	8.4	16.8	20.5	38.4	51.6	55.3	57.9	61.6	62.6	65.3	66.9
CR21XN	192	2.6	3.1	8.3	19.8	35.9	43.2	50.5	55.8	62.0	67.2	71.9	75.0
CR22XN	192	1.0	1.6	8.3	19.8	34.4	43.8	57.3	65.1	70.9	77.1	79.2	81.3
CR23XN	177	.6	.6	1.1	2.8	11.9	20.2	29.4	35.0	40.2	40.7	41.8	46.3
CR24XN	189	6.4	9.5	25.4	29.6	45.0	53.4	58.2	60.8	65.6	69.8	75.6	79.4
CT21XN	190	.5	.5	0.5	4.7	15.8	27.4	34.7	37.4	39.5	41.1	46.8	49.4
CT22XN	191	.5	.5	1.0	5.8	23.6	36.1	46.6	54.4	58.1	63.9	66.5	67.0
CT23XN	192	.....	.....	.....	1.0	6.8	12.5	21.9	25.0	28.7	31.2	33.3	38.0
CT24XN	191	.5	.5	.5	9.9	23.0	34.0	42.9	48.7	52.9	59.2	61.8	66.5

APPENDIX XXXIV.—VARIATION IN FAILURES IN LOTS OF COMMERCIAL PLATE.

TABLE 120.—PERCENTAGE OF FAILURES, DURING SPECIFIED PERIODS, IN ENAMELED CANS OF EACH LOT OF COMMERCIAL PLATE, 1917 EXPERIMENT, AVERAGE OF ALL PRODUCTS.

Code mark.	Number of cans.	Percentage of failures in cans packed—														
		3.5 mos.	4.5 mos.	5.5 mos.	6.5 mos.	8.5 mos.	9.5 mos.	10.5 mos.	11.5 mos.	12.5 mos.	13.5 mos.	14.5 mos.	15.5 mos.	16.5 mos.	17.5 mos.	19.5 mos.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
B1XN	144	1.4	1.4	4.9	9.0	25.7	34.0	38.9	46.5	55.5	61.1	66.0	69.5	73.0	78.5	83.3
B2XN	137	.....	.....	.7	8.8	29.9	36.5	46.0	54.0	58.3	64.2	69.3	74.5	79.6	86.2	86.8
B3XN	144	.....	2.1	7.6	15.6	31.9	39.6	42.3	50.0	54.2	56.2	59.7	61.8	63.8	66.7	72.2
B4XN	141	.7	4.3	11.7	20.6	46.8	53.9	56.0	60.3	65.3	70.9	72.3	73.7	75.8	75.8	78.0
B1AN	142	.....	.....	.....	.7	4.2	8.5	9.9	16.9	17.6	23.2	26.8	33.8	34.5	35.9	37.3
B2AN	143	.....	.....	.....	1.4	7.0	10.5	13.3	17.5	18.2	20.3	21.7	23.1	26.6	30.1	32.9
CB1XN	144	.....	2.1	4.9	15.6	31.9	38.2	51.3	58.3	70.2	72.2	76.4	77.1	79.8	85.4	88.2
CB2XN	143	3.5	4.9	12.6	25.9	45.4	54.6	60.2	61.6	66.4	70.0	70.0	70.7	70.7	71.3	74.2
CB3XN	143	.....	1.4	6.3	20.8	35.4	43.1	46.5	49.3	55.5	57.6	59.7	61.8	65.2	68.7	77.1
CB1AN	144	.....	.....	4.2	17.5	44.1	54.6	61.5	70.7	78.3	88.8	90.2	93.1	93.7	95.1	98.0
CB2AN	144	.....	.....	.....	6.9	25.7	37.5	43.7	50.0	56.2	65.3	72.9	77.1	83.3	88.9	92.3
H1XN	145	.7	2.8	9.0	18.6	35.9	42.8	44.8	49.7	55.2	60.0	60.7	64.8	72.4	77.9	86.9
H2XN	144	.7	.7	6.3	12.5	22.2	34.1	39.6	49.3	54.2	62.5	66.0	69.5	77.1	82.7	88.9
H3XN	144	4.3	6.4	12.8	37.7	52.5	61.0	65.9	70.2	78.0	83.0	83.6	84.4	87.2	88.6	90.1
H4XN	143	.....	.....	1.4	6.3	23.8	26.4	39.8	43.3	49.7	55.2	58.7	62.2	67.8	76.2	79.9
H1AN	142	.....	.....	.7	1.4	9.2	14.8	19.0	25.4	27.5	30.3	34.8	37.3	43.7	46.5	48.6
H2AN	143	.....	.....	.....	.....	.7	1.4	1.4	4.9	7.0	10.5	14.7	14.7	19.6	25.2	31.5
H3AN	142	.....	.....	.....	.7	3.5	6.3	6.9	9.8	12.7	15.5	20.4	25.3	30.3	36.6	44.3
CH1XN	142	.....	2.8	13.4	25.3	36.6	45.8	47.8	53.5	55.6	57.1	57.7	59.2	63.3	66.9	74.0
CH2XN	144	.....	4.2	11.8	22.9	46.5	54.2	59.7	66.0	70.1	76.4	78.5	82.0	85.4	89.6	93.7
CH3XN	138	.....	2.2	10.9	23.9	58.7	71.0	80.4	87.6	89.1	93.5	96.3	97.8	99.3	99.3	99.3
CH1AN	142	.....	.....	1.4	4.9	19.7	31.7	39.4	45.1	52.8	62.0	71.1	76.1	80.3	83.8	86.6
CH2AN	144	.....	.7	6.9	16.7	22.9	25.7	27.8	32.7	35.4	37.5	38.9	40.3	45.1	56.9	58.3
CH4ZN	144	.....	.....	.....	.....	6.3	7.6	9.7	13.2	20.8	29.2	32.6	40.9	47.2	54.8	59.7

APPENDIX XXV.—FAILURES IN EACH PRODUCT OF THE 1917 EXPERIMENT, BY HEATS OF STEEL.

TABLE 121.—PERCENTAGE OF FAILURES, AT SPECIFIED DATES, IN CANS OF APPLES PACKED IN EACH TYPE OF PLATE, NOVEMBER 13, 1917.

Code mark.	Number of cans.	Percentage of failures between date of packing, Nov. 13 1917 and—													
		June 1, 1918 (6.5 mos.).	Aug. 1, 1918 (8.5 mos.).	Sept. 1, 1918 (9.5 mos.).	Oct. 1, 1918 (10.5 mos.).	Nov. 1, 1918 (11.5 mos.).	Dec. 1, 1918 (12.5 mos.).	Jan. 1, 1919 (13.5 mos.).	Feb. 1, 1919 (14.5 mos.).	Mar. 1, 1919 (15.5 mos.).	Apr. 1, 1919 (16.5 mos.).	May 1, 1919 (17.5 mos.).	June 1, 1919 (18.5 mos.).	July 1, 1919 (19.5 mos.).	Aug. 1, 1919 (20.5 mos.).
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
R2XP	24	.....	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	29.2	41.7	50.0	58.3	58.3
R3XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	8.3	8.3	8.3	8.3
R4XP	24	.....	4.2	20.8	20.8	29.2	37.5	41.7	41.7	45.8	75.0	79.2	83.3	83.3	83.3
R5XP	24	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
R6XP	24	.....	.....	12.5	16.7	29.2	54.2	58.3	66.7	79.2	87.5	95.8	95.8	95.8	95.8
R7XP	24	.....	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	8.3	12.5
R2AP	24	.....	4.2	4.2	4.2	4.2	12.5	20.8	20.8	25.0	25.0	25.0	29.2	33.3	33.3
R3AP	24	.....	.....	.....	.....	.....	4.2	4.2	8.3	8.3	12.5	16.7	16.7	20.8	20.8
R4AP	24	.....	8.3	12.5	16.7	20.8	29.2	29.2	29.2	33.3	58.3	70.8	75.0	75.0	79.2
R6AP	24	.....	.....	.....	.....	4.2	12.5	16.7	16.7	20.8	50.0	70.8	70.8	75.0	79.2
R7AP	23	.....	.....	.....	.....	.....	.....	.....	.....	4.3	8.7	8.7	8.7	8.7	13.1
CR1XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	8.3	8.3	8.3
CR2XP	22	.....	.....	18.2	27.3	50.0	59.1	59.1	59.1	59.1	59.1	63.7	63.7	68.2	68.2
CR3XP	25	.....	.....	.....	.....	.....	.....	4.0	12.0	16.0	56.0	64.0	68.0	80.0	88.0
CR1AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	12.5	12.5	12.5	12.5
CR2AP	24	.....	4.2	8.3	8.3	25.0	45.8	45.8	45.8	50.0	58.3	58.3	62.5	66.7	70.8
CR3AP	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	47.8	56.5	69.6	69.6	73.9
T1XP	24	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
T2XP	24	.....	.....	.....	.....	.....	.....	.....	.....	4.2	37.5	41.7	45.8	45.8	45.8
T3XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	8.3	8.3	8.3	8.3
T4XP	24	.....	4.2	4.2	4.2	4.2	8.3	8.3	12.5	12.5	16.7	16.7	20.8	20.8	29.2
T5XP	24	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	4.2
T6XP	24	.....	.....	.....	.....	.....	.....	.....	.....	4.2	12.5	20.8	20.8	20.8	29.2
T7XP	24	4.2	4.2	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	12.5	16.7	25.0
T2AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	8.3	8.3	8.3	8.3
T3AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3
T4AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	8.3	8.3	8.3	8.3
T5AP	24	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	16.7	16.7	20.8	20.8	25.0
T6AP	24	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	8.3	12.5	20.8	20.8	25.0
T7AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	8.3	12.5	12.5	20.8

CT1XP	24						4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
CT2XP	24										41.7	45.8	45.8	45.8	45.8
CT3XP	24										29.2	29.2	37.5	50.0	70.8
CT1AP	24														
CT2AP	24						4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
CT3AP	24					4.2	4.2	4.2	4.2	4.2	29.2	33.3	33.3	41.7	41.7
H1XP	24		4.2	8.3	8.3	12.5	12.5	12.5	12.5	12.5	33.0	41.7	54.2	54.2	66.7
H2XP	24										25.0	25.0	25.0	25.0	29.2
CH2XP	24											4.2	4.2	4.2	4.2
CH3XP	24										4.2	4.2	4.2	8.3	8.3
CH1AP	24							4.2	4.2	16.7	25.0	37.5	37.5	45.8	45.8
CH4ZP	24									4.2	8.3	12.5	12.5	20.8	25.0
B1XP	24														12.5
B2XP	24														4.2
B3XP	24						4.2	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
B4XP	24										8.3	8.3	8.3	8.3	8.3
CB1XP	23										4.2	4.2	4.2	4.2	4.2
CB2XP	24						4.3	4.3	17.4	21.7	30.4	39.1	47.8	56.5	56.5
CB3XP	24						4.2	4.2	4.2	4.2	8.3	8.3	8.3	12.5	16.7
CB2AP	24					4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	16.7
ER3XP	24		4.2	8.3	8.3	8.3	12.5	12.5	12.5	16.7	37.5	50.0	54.2	54.2	58.3
AR3XP	24										8.3	8.3	8.3	8.3	20.8
ET4XP	24										4.2	4.2	4.2	4.2	4.2
AT4XP	24										16.7	20.8	25.0	25.0	33.3
AR3AP	23										8.3	20.8	29.2	29.2	41.7
SR3AP	24										4.3	4.3	8.7	17.4	17.4	34.8
AT4AP	24				4.2	4.2	4.2	4.2	4.2	8.3	20.8	25.0	41.7	41.7	41.7
ST4AP	24				8.3	8.3	8.3	8.3	8.3	8.3	25.0	37.5	41.7	45.8	62.5
												4.2	8.3	8.3	12.5

NOTE.—No failures occurred during the period of observation in cans of apples of the following lots of plate: R1XP, R1AP, R5AP, T1AP, H3XP, H4XP, H1AP, H2AP, H3AP, CH1XP, CH2AP, B1AP, B2AP, CB1AP.

TABLE 122.—PERCENTAGE OF FAILURES, AT SPECIFIED DATES, IN CANS OF CIDER PACKED IN EACH TYPE OF PLATE, NOVEMBER 12, 1917.

Code mark.	Number of cans.	Percentage of failures between date of packing, Nov. 12, 1917, and—													
		June 1, 1918 (6.5 mos.).	Aug. 1, 1918 (8.5 mos.).	Sept. 1, 1918 (9.5 mos.).	Oct. 1, 1918 (10.5 mos.).	Nov. 1, 1918 (11.5 mos.).	Dec. 1, 1918 (12.5 mos.).	Jan. 1, 1919 (13.5 mos.).	Feb. 1, 1919 (14.5 mos.).	Mar. 1, 1919 (15.5 mos.).	Apr. 1, 1919 (16.5 mos.).	May 1, 1919 (17.5 mos.).	June 1, 1919 (18.5 mos.).	July 1, 1919 (19.5 mos.).	Aug. 1 1919 (20.5 mos.).
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
R1XP	48	2.1	4.2	4.2	4.2	4.2	16.7	16.7	16.7	16.7	31.3	39.6	41.7	50.0	56.2
R2XP	48	.....	2.1	4.2	4.2	4.2	6.3	12.5	12.5	20.8	54.2	64.6	72.9	85.4	87.5
R3XP	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1	2.1	8.3
R4XP	48	.....	.....	.....	2.1	2.1	2.1	2.1	2.1	2.1	14.6	14.6	14.6	18.8	29.2
R6XP	48	.....	.....	.....	.....	.....	.....	2.1	4.2	6.3	16.7	18.8	18.8	18.8	27.1
R7XP	48	.....	.....	.....	.....	.....	.....	2.1	2.1	4.2	4.2	4.2	6.3	10.4	20.8
R1AP	47	.....	.....	.....	2.1	2.1	2.1	2.1	2.1	4.3	10.6	14.9	14.9	23.4	29.8
R2AP	48	.....	.....	2.1	6.3	14.6	41.7	43.8	50.0	66.7	81.3	87.5	87.5	87.5	95.8
R3AP	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1
R4AP	48	.....	.....	.....	.....	.....	.....	2.1	2.1	6.3	16.7	18.8	20.8	27.1	31.3
R5AP	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1	2.1	2.1	2.1	2.1
R7AP	48	.....	.....	.....	.....	.....	.....	.....	.....	2.1	4.2	4.2	4.2	4.2	6.3
CR1XP	45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.2	4.4	4.4	8.9
CR2XP	47	.....	.....	.....	.....	.....	2.1	4.3	6.4	17.0	53.2	57.5	59.6	78.7	89.4
CR3XP	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1
CR2AP	48	2.1	4.2	4.2	4.2	4.2	4.2	10.4	12.5	18.8	33.3	45.8	47.9	52.1	60.4
T1XP	49	.....	.....	.....	.....	.....	.....	2.0	2.0	2.0	4.1	8.2	10.4	10.4	16.3
T2XP	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1	2.1	2.1	2.1	2.1
T4XP	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.3	6.3	6.3	6.3	6.3
T5XP	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1
T6XP	47	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.4	6.4	6.4	6.4	8.5
T7XP	48	.....	.....	.....	.....	.....	.....	2.1	2.1	4.2	16.7	16.7	18.8	25.0	31.3
T1AP	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1	4.2	4.2	4.2	4.2
T2AP	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.0	4.0
T4AP	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1	2.1	2.1	2.1	6.3
T5AP	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1	2.1	2.1	2.1
T6AP	48	.....	.....	.....	.....	.....	.....	2.1	2.1	2.1	18.8	18.8	18.8	27.1	29.2
T7AP	48	.....	.....	.....	.....	.....	.....	2.1	2.1	2.1	6.3	6.3	8.3	14.6	16.7

CT3XP.....	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1	2.1	2.1	2.1	2.1
CT2AP.....	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1
R1XN.....	47	.....	29.8	53.2	53.2	57.5	76.7	78.7	93.6	97.9	97.9	100.0	.....	.....	.....
R2XN.....	50	36.0	54.0	74.0	82.0	94.0	96.0	96.0	96.0	96.0	100.0	.....	.....	.....	.....
R3XN.....	48	2.1	10.4	20.8	22.9	27.1	35.4	41.7	43.8	50.0	58.3	62.5	68.8	72.9	85.4
R4XN.....	49	10.2	30.6	42.8	53.1	63.3	89.8	89.8	93.9	93.9	95.9	97.9	97.9	97.9	97.9
R5XN.....	48	2.1	8.3	8.3	12.5	18.8	22.9	22.9	27.1	31.3	43.8	50.0	52.1	62.5	72.9
R6XN.....	48	.....	4.2	20.8	29.2	39.6	62.5	70.8	72.9	87.5	93.7	97.9	97.9	97.9	97.9
R7XN.....	48	16.7	33.3	47.9	52.1	62.5	83.3	85.4	89.6	93.7	95.8	100.0	.....	.....	.....
R1AN.....	47	.....	4.3	8.5	14.9	23.4	38.3	40.4	46.8	66.0	74.5	78.7	78.7	85.1	91.5
R2AN.....	48	14.6	39.6	56.2	66.7	79.2	87.5	89.6	91.7	95.8	97.9	100.0	.....	.....	.....
R3AN.....	46	.....	.....	.....	2.2	2.2	4.3	8.7	13.1	19.6	28.3	30.4	37.0	47.8	71.7
R4AN.....	48	.....	10.4	25.0	41.7	50.0	68.8	70.8	72.9	85.4	95.8	97.9	97.9	100.0	.....
R5AN.....	48	.....	.....	2.1	4.2	6.3	12.5	14.6	14.6	16.7	22.9	31.3	31.3	33.3	47.9
R6AN.....	43	.....	4.7	9.3	14.0	23.2	37.2	44.2	51.1	69.8	88.4	93.0	97.7	97.7	100.0
R7AN.....	48	2.1	14.6	22.9	25.0	27.1	39.6	45.8	50.0	66.7	79.2	81.3	83.3	85.4	97.9
CR1XN.....	48	2.1	16.7	22.9	27.1	31.3	41.7	41.7	41.7	45.8	54.2	66.7	70.8	72.9	75.0
CR2XN.....	49	22.5	62.4	91.9	96.0	98.0	98.0	98.0	98.0	100.0	.....	.....	.....	.....	.....
CR3XN.....	48	8.3	33.3	43.8	58.3	66.7	85.4	85.4	87.5	91.7	93.7	95.8	95.8	97.9	97.9
CR1AN.....	48	.....	2.1	8.3	12.5	16.7	29.2	31.3	33.3	41.7	56.2	58.3	64.6	75.0	85.4
CR2AN.....	48	4.2	52.1	66.7	70.8	72.9	85.4	87.5	87.5	95.8	95.8	97.9	100.0	.....	.....
CR3AN.....	48	2.1	25.0	29.2	33.3	37.5	54.2	54.2	56.2	58.3	68.8	75.0	81.3	85.4	93.7
T1XN.....	47	.....	.....	4.3	8.5	8.5	17.0	17.0	21.3	27.7	42.6	59.6	66.0	72.4	80.8
T2XN.....	48	.....	2.1	8.3	12.5	20.8	29.2	29.2	31.3	37.5	50.0	60.4	77.1	81.3	87.5
T3XN.....	48	.....	2.1	6.3	12.5	14.6	16.7	16.7	16.7	27.1	33.3	33.3	35.4	47.9	60.4
T4XN.....	48	8.3	27.1	37.5	50.0	60.4	81.3	87.5	89.6	95.8	100.0	.....	.....	.....	.....
T5XN.....	48	6.3	18.8	37.5	39.6	58.3	75.0	75.0	79.2	87.5	91.7	91.7	93.7	95.8	97.9
T6XN.....	48	2.1	18.8	31.3	33.3	39.6	45.8	54.2	60.4	75.0	81.3	87.5	89.6	93.7	100.0
T7XN.....	48	.....	14.6	22.9	27.1	35.4	52.1	60.4	64.6	70.8	79.2	89.6	93.7	95.8	95.8
T1AN.....	48	.....	.....	.....	2.1	2.1	2.1	2.1	2.1	2.1	2.1	4.2	8.3	14.6	25.0
T2AN.....	48	.....	2.1	2.1	2.1	4.2	6.3	8.3	8.3	18.8	20.8	39.6	41.7	54.2	66.7
T3AN.....	47	.....	.....	.....	.....	.....	4.3	4.3	4.3	8.5	8.5	14.9	21.3	25.5	38.3
T4AN.....	47	.....	12.8	21.3	25.5	34.1	51.1	55.3	63.9	78.7	89.4	93.6	95.7	95.7	95.7
T5AN.....	48	4.2	8.3	22.9	25.0	27.1	33.3	47.9	52.1	58.3	77.1	83.3	83.3	85.4	91.7
T6AN.....	48	.....	.....	.....	.....	2.1	12.5	20.8	22.9	37.5	58.3	75.0	83.3	85.4	85.4
T7AN.....	48	.....	.....	4.2	10.4	12.5	25.0	29.2	29.2	41.7	60.4	79.2	81.3	85.4	89.6

TABLE 122.—PERCENTAGE OF FAILURES, AT SPECIFIED DATES, IN CANS OF CIDER PACKED IN EACH TYPE OF PLATE, NOVEMBER 12, 1917.—*Continued.*

Code mark.	Number of cans.	Percentage of failures between date of packing, Nov. 12, 1917, and—													
		June 1, 1918 (6.5 mos.).	Aug. 1, 1918 (8.5 mos.).	Sept. 1, 1918 (9.5 mos.).	Oct. 1, 1918 (10.5 mos.).	Nov. 1 1918 (11.5 mos.).	Dec. 1, 1918 (12.5 mos.).	Jan. 1, 1919 (13.5 mos.).	Feb. 1, 1919 (14.5 mos.).	Mar. 1, 1919 (15.5 mos.).	Apr. 1, 1919 (16.5 mos.).	May 1, 1919 (17.5 mos.).	June 1, 1919 (18.5 mos.).	July 1, 1919 (19.5 mos.).	Aug. 1, 1919 (20.5 mos.).
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
CT1XN	48	.....	2.1	12.5	16.7	25.0	31.3	31.3	33.3	41.7	43.8	45.8	47.9	50.0	60.4
CT2XN	48	.....	8.3	16.7	25.0	37.5	52.1	52.1	54.2	58.3	64.6	72.9	77.1	83.3	87.5
CT3XN	48	4.2	39.6	47.9	60.4	64.6	72.9	81.3	85.4	93.7	93.7	97.9	97.9	97.9	100.0
CT1AN	48	.....	.....	.....	.....	4.2	8.3	10.4	10.4	16.7	22.9	35.4	41.7	47.9	58.3
CT2AN	47	.....	4.3	10.6	17.0	19.2	38.3	38.3	46.8	48.9	48.9	57.5	61.7	61.7	74.5
CT3AN	48	.....	16.7	33.3	41.7	47.9	56.2	56.2	58.3	60.4	64.6	68.8	70.8	81.3	81.3
ER3XP	47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1
ET4XP	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1
AT4XP	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2
AT4AP	47	.....	.....	.....	.....	.....	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	12.8
ER3XN	49	6.1	18.4	30.6	32.6	36.7	38.8	40.8	40.8	51.0	57.1	65.3	75.5	83.7	83.7
AR3XN	49	.....	.....	6.1	10.2	12.2	14.3	16.3	18.4	20.4	30.6	42.9	42.9	57.1	65.3
ET4XN	48	10.4	35.4	41.7	41.7	50.0	66.7	68.8	81.3	85.4	87.5	87.5	87.5	91.7	93.7
AT4XN	48	10.4	25.0	33.3	39.6	62.5	68.8	70.8	75.0	79.2	87.5	89.6	95.8	95.8	97.9
AR3AN	47	.....	10.6	12.8	21.3	25.5	44.7	44.7	46.8	51.1	61.7	70.2	76.6	80.8	85.1
SR3AN	48	.....	.....	.....	.....	.....	.....	2.1	2.1	2.1	6.3	10.4	10.4	12.5	18.8
AT4AN	47	19.2	36.2	38.3	42.6	42.6	66.0	70.2	72.4	76.6	80.8	87.2	89.4	93.6	97.9
ST4AN	48	.....	.....	.....	.....	.....	2.1	2.1	2.1	10.4	12.5	29.2	33.3	35.4	41.7
H1XP	48	.....	.....	4.2	4.2	4.2	4.2	10.4	10.4	12.5	18.8	22.9	25.0	31.3	35.4
H2XP	48	.....	2.1	2.1	2.1	2.1	6.3	8.3	8.3	10.4	12.5	12.5	12.5	14.6	16.7
H3XP	47	.....	.....	.....	.....	.....	.....	2.1	4.3	4.3	6.4	6.4	6.4	6.4	14.9
H4XP	48	.....	.....	.....	.....	.....	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	4.2
CH1XP	48	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	10.4	12.5	14.6	18.8	22.9
CH2XP	48	.....	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	4.2	4.2	4.2
CH3XP	48	.....	.....	.....	.....	.....	.....	.....	2.1	2.1	2.1	4.2	4.2	4.2	4.2
H1XN	48	2.1	2.1	4.2	6.3	12.5	18.8	25.0	25.0	31.3	47.9	62.5	70.8	79.2	85.4
H2XN	48	6.3	12.5	18.8	27.1	33.3	39.6	41.7	41.7	50.0	64.6	72.9	85.4	87.5	87.5
H3XN	48	2.1	29.2	50.0	62.5	64.6	79.2	83.3	83.3	85.4	91.7	93.7	95.8	97.9	97.9
H4XN	47	.....	.....	4.3	4.3	6.4	10.6	14.9	17.0	19.2	23.4	48.9	55.3	57.5	68.1

H1AN	48									4.2	4.2	4.2	4.2	4.2	4.2
H2AN	48		2.1	4.2	4.2	6.3	6.3	10.4	10.4	16.7	20.8	33.3	33.3	33.3	37.5
H3AN	48			6.3	6.3	6.3	10.4	12.5	14.6	20.8	22.9	31.3	33.3	35.4	41.7
CH1XN	48	4.2	4.2	6.3	6.3	8.3	10.4	10.4	12.5	12.5	18.8	25.0	35.4	43.8	47.9
CH2XN	49	4.1	30.6	40.8	49.0	57.2	65.3	69.4	75.6	81.7	85.7	91.8	96.0	96.0	96.0
CH3XN	44	15.9	52.3	70.5	84.1	92.2	95.5	97.7	100.0						
CH1AN	48	6.3	22.9	39.6	43.8	47.9	62.5	68.8	72.9	79.2	85.4	89.6	95.8	95.8	95.8
CH2AN	48					2.1	10.4	12.5	14.6	16.7	29.2	62.5	64.6	64.6	68.8
CH4ZN	48		10.4	10.4	12.5	12.5	27.1	27.1	27.1	29.2	35.4	41.7	45.8	47.9	58.3
B1XP	48					4.2	4.2	10.4	12.5	18.8	27.1	33.3	35.4	37.5	43.8
B2XP	48		2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	4.2	6.3	6.3	10.4
B4XP	48													2.1	2.1
CB1XP	48					2.1	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	6.3
CB2XP	48			2.1	2.1	2.1	4.2	4.2	4.2	6.3	6.3	6.3	6.3	6.3	6.3
CB1AP	48					2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
B1XN	48	6.3	20.8	29.2	31.3	31.3	45.8	45.8	45.8	52.1	58.3	64.6	66.7	68.8	72.9
B2XN	43			7.0	9.3	14.0	20.9	20.9	20.9	27.9	41.8	60.5	60.5	60.5	60.5
B3XN	48		2.1	4.2	6.3	14.6	22.9	22.9	22.9	29.2	33.3	35.4	37.5	39.6	43.8
B4XN	47		4.3	10.6	12.8	12.8	17.0	23.4	27.7	29.8	34.1	34.1	36.2	38.3	55.3
B1AN	48					2.1	2.1	4.2	4.2	6.3	6.3	6.3	6.3	6.3	16.7
B2AN	48						2.1	2.1	4.2	4.2	4.2	4.2	4.2	4.2	4.2
CB1XN	46	8.7	26.1	32.6	45.7	60.9	84.8	84.8	84.8	84.8	86.9	91.3	95.6	95.6	95.6
CB2XN	48	2.1	4.2	6.3	6.3	6.3	12.5	12.5	12.5	16.7	16.7	18.8	20.8	22.9	31.3
CB3XN	48		12.5	27.1	31.3	35.4	45.8	47.9	52.1	52.1	56.2	64.6	72.9	81.3	81.3
CB1AN	48	25.0	41.7	58.3	62.5	70.8	81.3	81.3	83.3	87.5	87.5	89.6	91.7	93.7	95.8
CB2AN	48	12.5	22.9	39.6	45.8	50.0	56.2	62.5	64.6	68.8	77.1	87.5	91.7	93.7	97.9

NOTE.—No failures occurred during the period of observation in cans of cider of the following lots of plate: R5XP, R6AP, CR1AP, CR3AP, T3AP, T3XP, CT1XP, CT2XP, CT1AP, CT3AP, AR3XP, AR3AP, SR3AP, ST4AP, H1AP, H2AP, H3AP, CH1AP, CH2AP, CH4ZP, B3XP, B1AP, B2AP, CB3XP, CB2AP.

TABLE 123.—PERCENTAGE OF FAILURES, AT SPECIFIED DATES, IN CANS OF BLUEBERRIES PACKED IN EACH TYPE OF PLATE, AUGUST 15, 1918.

Code mark.	Number of cans.	Percentage of failures between date of packing, Aug. 15, 1918, and—															
		Dec. 1, 1918 (3.5 mos.).	Jan. 1, 1919 (4.5 mos.).	Feb. 1, 1919 (5.5 mos.).	Mar. 1, 1919 (6.5 mos.).	Apr. 1, 1919 (7.5 mos.).	May 1, 1919 (8.5 mos.).	June 1, 1919 (9.5 mos.).	July 1, 1919 (10.5 mos.).	Aug. 1, 1919 (11.5 mos.).	Sept. 1, 1919 (12.5 mos.).	Oct. 1, 1919 (13.5 mos.).	Nov. 1, 1919 (14.5 mos.).	Dec. 1, 1920 (15.5 mos.).	Jan. 1, 1920 (16.5 mos.).	Feb. 15, 1920 (18 mos.).	Apr. 1, 1920 (19.5 mos.).
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
R1XP	24	.....	.....	.....	.....	.....	.....	.....	.....	4.2	12.5	12.5	20.8	20.8	20.8	29.2	41.7
R2XP	24	.....	.....	.....	.....	.....	.....	.....	.....	8.3	8.3	41.7	45.8	62.5	91.7	95.8	100.0
R3XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	8.3
R4XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	8.3	16.7	20.8
R5XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	12.5
R6XP	24	.....	.....	.....	.....	.....	.....	4.2	4.2	20.8	33.3	45.8	50.0	83.3	83.3	83.3	83.3
R7XP	24	.....	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	8.3	20.8	20.8	33.3	41.7	54.2
R1AP	24	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	12.5	16.7	16.7	29.2	41.7	54.2
R2AP	22	.....	.....	.....	.....	.....	.....	4.5	4.5	31.8	36.4	50.0	54.6	59.1	72.8	81.8	95.5
R3AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2
R4AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.5	16.7	29.2	62.5
R5AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	8.3	8.3	8.3	20.8
R6AP	24	.....	.....	.....	.....	.....	.....	.....	.....	8.3	12.5	20.8	37.5	54.2	62.5	66.7	70.8
R7AP	24	.....	.....	.....	.....	.....	.....	.....	.....	4.2	8.3	12.5	16.7	16.7	33.3	37.5	58.3
CR1XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	12.5	16.7
CR2XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	20.8	45.8	54.2	100.0
CR3XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	8.3	8.3	16.7	25.0	37.5
CR1AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	8.3	8.3	12.5	20.8	58.3
CR2AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	16.7	25.0	45.8	91.7
CR3AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	8.3	8.3	29.2
T1XP	24	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	29.2	33.3	41.7
T2XP	24	.....	.....	.....	.....	.....	.....	4.2	4.2	12.5	12.5	12.5	12.5	12.5	25.0	29.2	54.2
T3XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	4.2
T4XP	23	.....	.....	.....	.....	.....	.....	.....	4.3	4.3	4.3	8.7	13.1	17.4	21.7	34.8	47.8
T5XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	12.5	20.8	20.8	33.3	37.5
T6XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	8.3	16.7	25.0	37.5	66.7
T7XP	24	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	12.5	20.8	20.8	29.2	41.7
T1AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	12.5
T2AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	8.3
T3AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	8.3	8.3	8.3
T4AP	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	29.2	33.3	45.8
T5AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	12.5	20.8	33.3	41.7	66.7
T6AP	24	.....	.....	.....	.....	.....	.....	.....	.....	4.2	16.7	29.2	37.5	41.7	45.8	58.3	87.5
T7AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	12.5	20.8	45.8	62.5

CT2XP	24												4.2	8.3	8.3	16.7	20.8
CT3XP	22				9.1	9.1	9.1	13.6	13.6	13.6	13.6	13.6	18.2	18.2	18.2	27.3	36.4
CT1AP	24																
CT2AP	24																12.5
CT3AP	24													4.2	4.2	4.2	25.0
													4.2	4.2	16.7	29.2	33.3
R1XN	46			6.5	45.7	56.5	58.7	67.4	78.2	88.1	95.6	95.6	97.8	97.8	97.8	97.8	97.8
R2XN	46		21.7	34.8	71.7	84.8	95.6	97.8	100.0								
R3XN	48				16.7	41.7	43.8	47.9	52.1	75.0	77.1	83.3	83.3	89.6	97.9	97.9	97.9
R4XN	47		19.2	34.1	51.1	72.4	85.1	89.4	97.9	100.0							
R5XN	46				41.3	52.2	54.4	58.7	65.2	76.1	91.3	91.3	91.3	97.8	97.8	100.0	
R6XN	48		10.4	35.4	81.3	89.6	95.8	97.9	97.9	97.9	100.0						
R7XN	48		4.2	33.3	79.2	91.7	95.8	95.8	95.8	100.0							
R1AN	48				8.3	12.5	14.6	20.8	27.1	39.6	54.2	60.4	70.8	72.9	83.3	91.7	93.7
R2AN	47		10.6	23.4	55.3	63.9	72.4	80.8	87.2	93.6	95.7	100.0					
R3AN	48				10.4	18.8	27.1	43.8	60.4	66.7	77.1	81.3	83.3	87.5	87.5	93.7	97.9
R4AN	48			2.1	25.0	33.3	60.4	77.1	87.5	93.7	97.9	97.9	97.9	100.0			
R5AN	48					2.1	4.2	6.3	10.4	20.8	27.1	39.6	54.2	66.7	68.8	85.4	95.8
R6AN	46	2.2	17.4	39.2	78.2	88.1	97.8	97.8	97.8	97.8	97.8	97.8	100.0				
R7AN	48		2.1	8.3	33.3	45.8	54.2	62.5	79.2	85.4	93.7	95.8	100.0				
CR1XN	48			4.2	22.9	33.3	43.8	58.3	64.6	70.8	75.0	79.2	81.3	81.3	85.4	85.4	89.6
CR2XN	47		19.2	44.7	85.1	87.2	91.5	93.6	95.7	97.9	100.0						
CR3XN	48			14.6	39.6	52.1	62.5	70.8	79.2	91.7	95.8	97.9	97.9	97.9	100.0		
CR1AN	48				2.1	6.3	14.6	27.1	33.3	54.2	58.3	70.8	77.1	77.1	87.5	87.5	91.7
CR2AN	47		2.1	14.9	40.4	59.6	70.2	76.6	85.1	97.9	100.0						
CR3AN	48				4.2	6.3	18.8	33.3	52.1	70.8	77.1	83.3	91.7	91.7	93.7	100.0	
T1XN	48		2.1	2.1	16.7	27.1	29.2	33.3	37.5	60.4	64.6	66.7	77.1	77.1	91.7	95.8	95.8
T2XN	47				27.7	34.1	38.3	42.6	53.2	72.4	83.0	89.4	93.6	97.9	97.9	97.9	97.9
T3XN	48		2.1	2.1	43.8	50.0	52.1	64.6	77.1	87.5	91.7	95.8	97.9	97.9	100.0		
T4XN	48		2.1	16.7	64.6	75.0	81.3	93.7	95.8	97.9	97.9	100.0					
T5XN	48		2.1	16.7	62.5	68.8	75.0	85.4	93.7	93.7	97.9	100.0					
T6XN	47		12.8	21.3	61.7	70.2	78.7	85.1	91.5	95.7	97.9	97.9	100.0				
T7XN	47		6.4	12.8	66.0	68.1	78.7	87.2	91.5	93.6	95.7	95.7	97.9	97.9	97.9	97.9	97.9
T1AN	47			2.1	4.3	4.3	4.3	4.3	6.4	31.9	34.1	36.2	40.4	57.5	63.9	76.7	89.4
T2AN	48				14.6	16.7	18.8	25.0	29.2	39.6	45.8	54.2	62.5	68.8	75.0	79.2	87.5
T3AN	48		2.1	2.1	6.3	10.4	14.6	25.0	37.5	62.5	87.5	89.6	89.6	89.6	91.7	95.8	95.8
T4AN	48		4.2	12.5	29.2	45.8	56.2	72.9	81.3	85.4	89.6	89.6	95.8	97.9	100.0		
T5AN	48				10.4	18.8	29.2	43.8	54.2	72.9	75.0	77.1	89.6	93.7	100.0		
T6AN	46		6.5	17.4	43.5	47.8	60.9	71.7	86.9	93.5	93.5	95.6	100.0				
T7AN	40	2.5	2.5	2.5	20.0	25.0	27.5	40.0	57.5	75.0	85.0	85.0	85.0	90.0	95.0	100.0	

TABLE 123.—PERCENTAGE OF FAILURES, AT SPECIFIED DATES, IN CANS OF BLUEBERRIES PACKED IN EACH TYPE OF PLATE, AUGUST 15, 1918.—*Continued.*

Code mark.	Number of cans.	Percentage of failures between date of packing, Aug. 15, 1918, and—															
		Dec. 1, 1918 (3.5 mos.).	Jan. 1, 1919 (4.5 mos.).	Feb. 1, 1919 (5.5 mos.).	Mar. 1, 1919 (6.5 mos.).	Apr. 1, 1919 (7.5 mos.).	May 1, 1919 (8.5 mos.).	June 1, 1919 (9.5 mos.).	July 1, 1919 (10.5 mos.).	Aug. 1, 1919 (11.5 mos.).	Sept. 1, 1919 (12.5 mos.).	Oct. 1, 1919 (13.5 mos.).	Nov. 1, 1919 (14.5 mos.).	Dec. 1, 1920 (15.5 mos.).	Jan. 1, 1920 (16.5 mos.).	Feb. 15, 1920 (18 mos.).	Apr. 1, 1920 (19.5 mos.).
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
CT1XN	48	.....	.....	.....	14.6	20.8	22.9	22.9	27.1	47.9	54.2	62.5	72.9	77.1	83.3	87.5	89.6
CT2XN	48	.....	.....	.....	4.2	12.5	16.7	35.4	39.6	56.2	64.6	77.1	85.4	85.4	91.7	97.9	97.9
CT3XN	46	.....	.....	2.2	45.7	65.2	82.6	88.1	88.1	88.1	97.8	97.8	97.8	97.8	97.8	97.8	97.8
CT1AN	48	.....	.....	.....	2.1	2.1	4.2	8.3	12.5	27.1	31.3	43.8	54.2	62.5	70.8	72.9	87.5
CT2AN	48	.....	.....	.....	2.1	2.1	6.3	10.4	10.4	22.9	43.8	62.5	72.9	85.4	85.4	91.7	97.9
CT3AN	46	.....	.....	.....	17.0	31.9	44.7	63.9	74.5	85.1	93.6	95.7	97.9	97.9	97.9	97.9	97.9
ER3XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	16.7	20.8
AR3XP	24	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	4.2	16.7	16.7
ET4XP	24	.....	.....	.....	4.2	4.2	4.2	4.2	8.3	20.8	25.0	37.5	45.8	45.8	50.0	62.5	66.7
AT4XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	8.3	8.3
AR3AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	12.5
SR3AP	24	.....	.....	.....	.....	.....	.....	.....	.....	4.2	8.3	16.7	16.7	16.7	20.8	29.2	45.8
AT4AP	24	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	4.2	20.8	45.8	45.8	45.8	50.0
ST4AP	24	.....	.....	.....	.....	.....	4.2	4.2	4.2	12.5	20.8	25.0	29.2	37.5	41.7	54.2	75.0
ER3XN	46	.....	.....	2.2	43.5	60.9	60.9	69.6	76.1	82.6	84.8	86.9	88.1	93.5	97.8	97.8	97.8
AR3XN	48	.....	.....	.....	35.4	50.0	56.2	64.6	68.8	79.2	85.4	89.6	91.7	93.7	97.9	97.9	97.9
ET4XN	47	.....	4.3	12.8	74.5	85.1	87.2	93.6	95.7	95.7	97.9	97.9	97.9	97.9	97.9	97.9	97.9
AT4XN	47	.....	.....	2.1	34.1	51.1	59.6	59.6	66.0	76.6	83.0	85.1	85.1	85.1	91.5	91.5	93.6
AR3AN	48	.....	.....	4.2	16.7	20.8	29.2	41.7	45.8	56.2	58.3	68.8	75.0	79.2	89.6	95.8	97.9
SR3AN	48	.....	.....	.....	.....	.....	.....	.....	2.1	4.2	6.3	6.3	10.4	12.5	16.7	18.8	35.4
AT4AN	46	.....	2.2	40.3	30.4	47.8	50.0	58.7	60.9	67.4	73.9	78.2	80.4	80.4	91.3	93.5	93.5
ST4AN	48	.....	.....	.....	2.1	6.3	6.3	10.4	18.8	31.3	35.4	41.7	47.9	60.4	62.5	70.8	91.7
H1XP	24	.....	.....	.....	.....	.....	.....	.....	.....	4.2	8.3	16.7	16.7	16.7	16.7	20.8	79.2
H2XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	12.5
H3XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.5	12.5	16.7	20.8	25.0	37.5	54.2
H4XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	8.3	16.7
H1AP	23	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	4.2	16.7	33.3
H2AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	8.3
H3AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	8.3	8.3	12.5
CH1XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	25.0	45.8
CH3XP	24	.....	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	8.3	8.3	8.3	25.0

CH1AP	24												4.2	16.7	20.8	54.2
CH2AP	24															8.3
CH4ZP	24											4.2	16.7	16.7	25.0	25.0
H1XN	49	2.2	8.2	26.5	53.1	77.6	77.6	89.8	89.8	89.8	94.0	94.0	94.0	98.0	98.0	98.0
H2XN	48			12.5	22.9	33.3	39.6	60.4	60.4	79.2	83.3	91.7	97.9	97.9	100.0	
H3XN	48	12.5	18.8	37.5	72.9	79.2	81.3	85.4	85.4	91.7	95.8	97.9	97.9	97.9	97.9	97.9
H4XN	48			4.2	16.7	25.0	25.0	45.8	50.0	56.2	66.7	75.0	83.3	89.6	93.7	93.7
H1AN	47			2.1	4.3	8.5	8.5	19.2	21.3	36.2	42.6	46.8	55.3	61.7	74.5	80.8	87.2
H2AN	47									6.4	12.8	19.2	31.9	31.9	38.3	48.9	55.3
H3AN	46				2.2	8.7	10.9	13.1	15.2	23.9	28.3	34.8	45.7	50.0	58.7	65.2	73.9
CH1XN	48		6.3	37.5	68.8	72.9	75.0	87.5	89.6	95.8	95.8	95.8	95.8	95.8	97.9	100.0	
CH2XN	47		12.8	36.2	66.0	83.0	97.9	100.0									
CH3XN	46		6.5	32.6	56.5	63.1	86.9	95.6	100.0								
CH1AN	47			4.3	8.5	19.2	21.3	38.3	46.8	57.5	66.0	74.5	83.0	85.1	89.4	91.5	93.6
CH2AN	48		2.1	20.8	50.0	60.4	68.8	75.0	81.3	93.7	93.7	93.7	93.7	95.8	97.9	97.9	100.0
CH4ZN	48							2.1	6.3	8.3	14.6	20.8	25.0	45.8	52.1	66.7	68.8
B1XP	24															4.2	20.8
B2XP	24										4.2	4.2	4.2	4.2	4.2	4.2	4.2
B3XP	24									16.7	33.3	37.5	54.2	66.7	75.0	79.2	87.5
B4XP	24									4.2	12.5	12.5	25.0	33.3	37.5	45.8	50.0
B1AP	24														4.2	29.2	41.7
B2AP	24												4.2	8.3	8.3	20.8	25.0
CB1XP	24									4.2	4.2	4.2	4.2	8.3	8.3	12.5	16.7
CB2XP	24												12.5	20.8	50.0	58.3	79.2
CB1AP	24						4.2	4.2	4.2	4.2	8.3	12.5	12.5	16.7	20.8	50.0	50.0
CB2AP	24										4.2	4.2	16.7	20.8	41.7	54.2	62.5
B1XN	48			4.2	10.4	18.8	20.8	31.3	33.3	47.9	58.3	64.6	72.9	77.1	81.3	83.3	89.6
B2XN	48				22.9	37.5	43.8	45.8	62.5	79.2	81.3	85.4	93.7	95.8	97.9	97.9	97.9
B3XN	48		6.3	20.8	41.7	56.2	62.5	77.1	81.3	87.5	87.5	89.6	93.7	93.7	93.7	95.8	97.9
B4XN	48		4.2	18.8	43.8	56.2	66.7	72.9	77.1	83.3	91.7	97.9	97.9	97.9	97.9	97.9	100.0
B1AN	48				2.1	4.2	6.3	16.7	16.7	31.3	33.3	37.5	47.9	62.5	64.6	68.8	70.8
B2AN	47				4.3	4.3	8.5	17.0	21.3	27.7	27.7	27.7	29.8	34.1	42.6	51.1	55.3
CB1XN	49		6.1	14.3	36.7	59.2	65.3	71.5	85.8	89.8	98.0	98.0	100.0				
CB2XN	48	10.4	14.6	31.3	62.5	70.8	79.2	89.6	93.7	93.7	95.8	95.8	100.0				
CB3XN	48		4.2	18.8	62.5	79.2	85.4	91.7	93.7	97.9	97.9	100.0					
CB1AN	47			12.8	27.7	44.7	55.3	66.0	76.6	87.2	93.6	95.7	95.7	97.9	100.0		
CB2AN	48				6.3	6.3	8.3	20.8	27.1	37.5	45.8	56.2	77.1	81.3	85.4	87.5	89.6

NOTE.—No failures occurred during the period of observation in cans of blueberries of the following lots of plate: CT1XP, CH2XP, CB3XP.

TABLE 124.—PERCENTAGE OF FAILURES, AT SPECIFIED DATES, IN CANS OF STRAWBERRIES PACKED IN EACH TYPE OF PLATE, JUNE 21, 1918.

Code mark.	Number of cans.	Percentage of failures between date of packing, June 21, 1918, and—																		
		Sept. 1, 1918 (2.5 mos.).	Oct. 1, 1918 (3.5 mos.).	Nov. 1, 1918 (4.5 mos.).	Dec. 1, 1918 (5.5 mos.).	Jan. 1, 1919 (6.5 mos.).	Feb. 1, 1919 (7.5 mos.).	Mar. 1, 1919 (8.5 mos.).	Apr. 1, 1919 (9.5 mos.).	May 1, 1919 (10.5 mos.).	June 1, 1919 (11.5 mos.).	July 1, 1919 (12.5 mos.).	Aug. 1, 1919 (13.5 mos.).	Sept. 1, 1919 (14.5 mos.).	Oct. 1, 1919 (15.5 mos.).	Nov. 1, 1919 (16.5 mos.).	Dec. 1, 1919 (17.5 mos.).	Jan. 1, 1920 (18.5 mos.).	Feb. 15, 1920 (20 mos.).	Apr. 1, 1920 (21.5 mos.).
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
R2XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2	4.2	4.2
R3XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2
R4XP	24	.....	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	8.3	16.7	16.7	16.7
R6XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	8.3	8.3	8.3	8.3	16.7	16.7	16.7	16.7	16.7
R3AP	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.3	8.7	8.7	8.7	8.7
R4AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	8.3	8.3	8.3
CR3XP	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.3	8.7	8.7	21.7	21.7	21.7	21.7
CR3AP	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.3	4.3	4.3	4.3	4.3
T3XP	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	26.1	26.1	26.1	26.1
T7XP	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
T3AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.3	12.5	20.8	25.0
T4AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	4.2	4.2	4.2
T6AP	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.5	9.0	9.0	9.0	9.0
CT3XP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	70.8	83.3	83.3	83.3	83.3
CT3AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	33.3	37.5	41.7	62.5	66.7
R1XN	48	.....	.....	.....	2.1	2.1	2.1	6.3	25.0	27.1	35.4	35.4	52.1	54.2	54.2	60.4	64.6	66.7	66.7	68.8
R2XN	48	4.2	18.8	27.1	47.9	56.2	66.7	87.5	89.6	97.9	100.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
R3XN	48	.....	.....	.....	2.1	4.2	8.3	47.9	52.1	62.5	70.8	72.9	79.2	83.3	93.7	93.7	97.9	97.9	97.9	97.9
R4XN	48	.....	.....	.....	16.7	29.2	43.8	89.6	91.7	95.8	95.8	97.9	97.9	100.0	.....	.....	.....	.....	.....	.....
R5XN	49	.....	.....	.....	.....	.....	.....	28.6	42.8	42.8	46.9	46.9	61.2	61.2	63.3	67.3	71.4	73.5	75.5	79.6
R6XN	48	.....	2.1	2.1	4.2	22.9	45.8	93.7	97.9	97.9	97.9	97.9	100.0	.....	.....	.....	.....	.....	.....	.....
R7XN	48	.....	.....	4.2	29.2	50.0	62.5	97.9	100.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R1AN	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1	8.3	25.0	33.3	41.7	52.1	58.3	62.5	64.6	68.8
R2AN	48	.....	4.2	8.3	14.6	22.9	27.1	60.4	68.8	75.0	81.3	85.4	87.5	87.5	87.5	91.7	93.7	93.7	95.8	95.8
R3AN	48	.....	.....	2.1	2.1	8.3	8.3	41.7	45.8	50.0	64.6	70.8	77.1	79.2	79.2	81.3	83.3	83.3	83.3	83.3
R4AN	48	.....	.....	.....	2.1	2.1	8.3	66.7	81.3	85.4	91.7	93.7	95.8	97.9	97.9	97.9	97.9	97.9	97.9	97.9
R5AN	48	.....	.....	.....	.....	.....	2.1	37.5	52.1	60.4	62.5	64.6	68.8	68.8	79.2	79.2	81.3	83.3	85.4	87.5
R6AN	48	.....	.....	8.3	16.7	31.3	39.6	87.5	97.9	97.9	100.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
R7AN	48	.....	.....	.....	.....	8.3	10.4	56.2	68.8	79.2	83.3	91.7	95.8	95.8	95.8	97.9	97.9	97.9	97.9	97.9

CR1XN	48							2.1	2.1	4.2	4.2	4.2	12.5	12.5	20.8	29.2	29.2	33.3	33.3	35.4
CR2XN	43				4.7	11.6	16.3	48.8	58.1	74.4	76.8	86.1	90.7	97.7	97.7	97.7	100.0			
CR3XN	47			2.1	2.1	2.1	2.1	8.5	17.0	25.5	34.1	34.1	53.2	61.7	63.9	63.9	72.4	74.5	74.5	78.7
CR1AN	48							6.3	16.7	20.8	22.9	27.1	35.4	45.8	47.9	54.2	54.2	54.2	56.2	58.3
CR2AN	47				2.1	8.5	14.9	46.8	57.5	74.5	80.8	87.2	93.6	95.7	95.7	95.7	97.9	97.9	97.9	100.0
CR3AN	49							10.2	18.4	30.6	38.8	49.0	57.2	57.2	57.2	71.5	73.5	77.6	79.7	81.7
T1XN	48							14.6	14.6	22.9	29.2	35.4	39.6	52.1	58.3	68.8	72.9	75.0	77.1	79.2
T2XN	47							21.3	31.9	42.6	53.2	53.2	68.1	74.5	76.6	80.8	83.0	87.2	89.4	91.5
T3XN	48							22.9	27.1	39.6	47.9	52.1	62.5	70.8	75.0	77.1	79.2	81.3	83.3	85.4
T4XN	48			4.2	6.3	20.8	33.3	35.4	83.3	87.5	91.7	91.7	91.7	93.7	93.7	93.7	93.7	93.7	97.9	97.9
T5XN	48			4.2	27.1	45.8	60.4	85.4	87.5	89.6	93.7	93.7	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8
T6XN	48		4.2	12.5	25.0	33.3	37.5	79.2	85.4	85.4	89.6	89.6	93.7	95.8	97.9	97.9	100.0			
T7XN	48			2.1	12.5	14.6	16.7	75.0	79.2	87.5	89.6	89.6	89.6	91.7	93.7	95.8	95.8	97.9	97.9	97.9
T1AN	48							2.1	6.3	8.3	12.5	12.5	16.7	20.8	22.9	27.1	31.3	35.4	35.4	39.6
T2AN	48							29.2	35.4	43.8	52.1	52.1	60.4	64.6	66.7	66.7	75.0	77.1	83.3	85.4
T3AN	47							8.5	19.2	27.7	31.9	36.2	42.6	55.3	55.3	61.7	68.1	70.2	74.5	76.6
T4AN	48		4.2	8.3	14.6	20.8	31.3	64.6	75.0	81.3	85.4	85.4	93.7	95.8	97.9	100.0				
T5AN	48		4.2	16.7	35.4	41.7	52.1	85.4	91.7	100.0										
T6AN	48			4.2	6.3	10.4	20.8	83.3	91.7	95.8	95.8	95.8	100.0							
T7AN	48						4.2	66.7	75.0	79.2	81.3	83.3	85.4	89.6	89.6	89.6	89.6	89.6	91.7	93.7
CT1XN	47							2.1	2.1	2.1	4.3	4.3	6.4	8.5	10.6	17.0	19.2	19.2	21.3	23.4
CT2XN	47							6.4	6.4	6.4	10.6	12.8	27.7	29.8	31.9	46.8	50.1	53.2	63.9	70.2
CT3XN	47						2.1	27.7	42.6	51.1	63.9	74.5	87.2	95.7	95.7	97.9	97.9	100.0		
CT1AN	47							2.1	2.1	2.1	6.4	6.4	17.0	19.2	19.2	23.4	27.7	29.8	34.1	42.6
CT2AN	47							2.1	6.4	10.6	14.9	14.9	27.7	36.2	36.2	42.6	44.7	46.8	51.1	51.1
CT3AN	48							8.3	22.9	29.2	43.8	54.2	64.6	72.9	79.2	79.2	83.3	85.4	85.4	85.4
ER3XN	48		2.1	4.2	22.9	31.3	39.6	89.6	93.7	95.8	95.8	100.0								
AR3XN	48					2.1	4.2	27.1	33.3	37.5	43.8	45.8	50.0	50.0	52.1	56.2	56.2	62.5	64.6	68.8
ET4XN	48		2.1	8.3	22.9	41.7	54.2	93.7	95.8	97.9	97.9	100.0								
AT4XN	48				12.5	25.0	37.5	79.2	79.2	85.4	91.7	91.7	93.7	95.8	95.8	97.9	97.9	100.0		
AR3AN	48			2.1	4.2	6.3	12.5	54.2	62.5	70.8	75.0	79.2	87.5	89.6	91.7	91.7	91.7	91.7	91.7	91.7
SR3AN	48							33.3	41.7	45.8	50.0	50.0	60.4	62.5	70.8	72.9	72.9	79.2	81.3	83.3
AT4AN	48		4.2	6.3	14.6	22.9	31.3	66.7	75.0	81.3	85.4	85.4	87.5	91.7	93.7	93.7	93.7	95.8	95.8	97.9
ST4AN	48						2.1	27.1	29.2	31.3	35.4	37.5	50.0	50.0	58.3	60.4	68.8	68.8	68.8	68.8
H1XP	24				4.2	4.2	8.3	16.7	16.7	20.8	20.8	20.8	20.8	20.8	25.0	25.0	29.2	29.2	29.2	29.2
CH3XP	21													14.3	14.3	14.3	14.3	14.3	14.3	14.3
H1XN	48						2.1	27.1	33.3	37.5	45.8	52.1	60.4	62.5	64.6	70.8	72.9	81.3	83.3	85.4
H2XN	48		2.1	2.1	6.3	8.3	10.4	14.6	22.9	31.3	35.4	39.6	54.2	58.3	60.4	66.7	75.0	79.2	79.2	81.3
H3XN	45					6.7	8.9	46.7	46.7	48.9	53.3	57.8	66.7	68.9	68.9	71.1	73.3	73.3	73.3	73.3
H4XN	48					2.1	6.3	45.8	58.3	64.6	66.7	70.8	75.0	75.0	77.1	85.4	85.4	87.5	87.5	87.5

TABLE 124.—PERCENTAGE OF FAILURES, AT SPECIFIED DATES, IN CANS OF STRAWBERRIES PACKED IN EACH TYPE OF PLATE, JUNE 21, 1918.—*Continued.*

Code mark.	Number of cans.	Percentage of failures between date of packing, June 21, 1918, and—																	
		Sept. 1, 1918 (2.5 mos.).	Oct. 1, 1918 (3.5 mos.).	Nov. 1, 1918 (4.5 mos.)	Dec. 1, 1918 (5.5 mos.).	Jan. 1, 1919 (6.5 mos.).	Feb. 1, 1919 (7.5 mos.).	Mar. 1, 1919 (8.5 mos.).	Apr. 1, 1919 (9.5 mos.).	May 1, 1919 (10.5 mos.).	June 1, 1919 (11.5 mos.).	July 1, 1919 (12.5 mos.).	Aug. 1, 1919 (13.5 mos.).	Sept. 1, 1919 (14.5 mos.).	Oct. 1, 1919 (15.5 mos.).	Nov. 1, 1919 (16.5 mos.).	Dec. 1, 1919 (17.5 mos.).	Jan. 1, 1920 (18.5 mos.).	Feb. 15, 1920 (20 mos.).	Apr. 1, 1920 (21.5 mos.).
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
H1AN	47	.....	.....	.....	.....	.....	.....	19.2	25.5	36.2	40.4	40.4	44.7	46.8	51.1	53.2	55.3	55.3	55.3	55.3
H2AN	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1	2.1	2.1	2.1	2.1	4.2	6.3	6.3	6.3	8.3
H3AN	48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.1	6.3	10.4	14.6	16.7	25.0	27.1
CH1XN	48	.....	.....	2.1	2.1	2.1	8.3	29.2	41.7	45.8	54.2	58.3	62.5	62.5	66.7	70.8	72.9	72.9	75.0	77.1
CH2XN	48	.....	.....	.....	.....	.....	.....	12.5	22.9	31.3	41.7	45.8	60.4	60.4	64.6	70.8	77.1	83.3	85.4	91.7
CH3XN	48	.....	.....	.....	.....	.....	4.2	37.5	47.9	58.3	70.8	72.9	83.3	89.6	93.7	97.9	97.9	97.9	97.9	97.9
CH1AN	47	.....	.....	.....	.....	.....	2.1	14.9	17.0	27.7	29.8	29.8	42.6	57.5	63.9	66.0	70.2	70.2	70.2	74.5
CH2AN	48	.....	.....	.....	.....	.....	.....	.....	2.1	2.1	2.1	2.1	6.3	8.3	8.3	8.3	10.4	10.4	10.4	10.4
CH4ZN	48	.....	.....	.....	.....	.....	.....	8.3	10.4	10.4	18.8	20.8	39.6	45.8	47.9	54.2	54.2	62.5	62.5	68.8
B2XP	21	.....	.....	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
CB2XP	24	.....	.....	.....	.....	4.2	8.3	8.3	8.3	8.3	8.3	12.5	16.7	16.7	20.8	20.8	20.8	20.8	20.8	20.8
CB2AP	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.2	12.5	12.5	12.5	12.5	12.5
B1XN	48	.....	4.2	4.2	10.4	10.4	12.5	35.4	41.7	52.1	60.4	62.5	72.9	79.2	79.2	79.2	87.5	91.7	91.7	93.7
B2XN	47	.....	.....	.....	2.1	2.1	4.3	42.6	53.2	61.7	63.9	68.1	80.8	87.2	93.6	93.6	95.7	97.9	97.9	97.9
B3XN	48	.....	.....	.....	2.1	4.2	4.2	31.3	37.5	39.6	47.9	52.1	56.2	62.5	62.5	64.6	68.8	77.1	79.2	85.4
B4XN	46	.....	2.2	8.7	15.2	17.4	17.4	69.6	78.2	78.2	84.8	86.9	91.3	91.3	93.5	95.6	95.6	95.6	95.6	95.6
B1AN	46	.....	.....	.....	.....	.....	.....	6.5	8.7	13.1	17.4	17.4	28.3	28.3	32.6	32.6	32.6	34.8	34.8	37.0
B2AN	48	.....	.....	.....	.....	.....	.....	12.5	14.6	18.8	22.9	25.0	29.2	31:3	31.3	33.3	35.4	37.5	39.6	45.8
CB1XN	49	.....	.....	.....	.....	.....	.....	4.1	10.2	22.4	24.5	28.6	34.7	44.9	46.9	53.1	65.3	69.4	69.4	71.5
CB2XN	47	.....	.....	.....	6.4	12.8	17.0	53.2	68.1	80.8	83.0	91.5	95.7	95.7	95.7	95.7	95.7	100.0	.....	.....
CB3XN	48	.....	.....	.....	.....	.....	.....	8.3	10.4	14.6	14.6	22.9	25.0	27.1	33.3	39.6	41.7	45.8	50.0	52.1
CB1AN	48	.....	.....	.....	.....	.....	2.1	35.4	39.6	45.8	54.2	60.4	89.6	91.7	93.7	93.7	95.8	97.9	100.0	.....
CB2AN	48	.....	.....	.....	.....	2.1	2.1	45.8	52.1	58.3	62.5	66.7	77.1	77.1	81.3	87.5	91.7	95.8	95.8	97.9

NOTE.—No failures occurred during the period of observation in cans of strawberries of the following lots of plate: R1XP, R5XP, R7XP, R1AP, R2AP, R5AP, R6AP, R7AP, CR1XP, CR2XP, CR1AP, CR2AP, T1XP, T2XP, T4XP, T5XP, T6XP, T1AP, T2AP, T5AP, T7AP, CT1XP, CT2XP, CT1AP, CT2AP, ER3XP, AR3XP, ET4XP, AT4XP. AR3AP, SR3AP, AT4AP, ST4AP, H2XP, I XP, H4XP, H1AP, H2AP, H3AP, CH1XP, CH2XP, CH1AP, CH2AP, CH4ZP, B1XP, B3XP, B4XP, B1AP, B2AP, CB1XP, CB3XP, CB1AP.

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2 NOV 1962